Transport Canada

Development

Transports Canada

Développement

TP 5298E

Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Summary Report

Prepared for

Transportation Development Centre

MARCH 1984

CA1
DTC 845
84
L12
c. 2

Canada

TP 5288 E

LABORATORY EVALUATION OF FLYASH CEMENT AND LIGNIN CELLULOSE CEMENT AS SOIL STABILIZERS

SUMMARY REPORT

Prepared for:

TRANSPORTATION DEVELOPMENT CENTRE

by:

MICHAEL D. GRAHAM, P.ENG. AND C.B. DAWLEY, P.ENG.
EBA ENGINEERING CONSULTANTS LTD.

Library and Information Centre/
Centre de Documentation (GSLA)
RECEIVED - REÇU LE
AUG 23 1984
Transport Canada / Transports Canada

MARCH, 1984

"The contents of this report reflect the views of the contractor and not necessarily the official views or policies of the Transportation Development Centre".

Egalement disponible en français

REPORT DOCUMENTATION FORM

1. Transport Canada Report No. TP 5288E	2. TDC Project No. 4925,4926	3. Recipient's Catalogue No.

4. Title and Subtitle Laboratory evaluation of flyash cement and lignin cellulose cement as soil stabilizers Summary Report	5. Report Date March, 1984 6. Performing Organization Report No. 0304-31264-002
7. Author(s) M.D. Graham and C.B. Dawley	8. Transport Canada File No. D1465-413
9. Performing Organization Name and Address EBA Engineering Consultants Ltd. 7175 - 12 Street S.E. Calgary, Alberta T2H 2S6	10 DSS File No. 14SD.T8200-2-2582 11. DSS or Transport Canada Contract No 1SD83-00026
12. Sponsoring Agency Name and Address Transportation Development Centre 1000 Sherbrooke Street West Suite 2421 Montreal Quebec H3A 2R3 Supply & Services Canada 88 Metcalfe Street Ottawa, Ontario K1A 0B5	13. Type of Report and Period Covered Summary Jun 83 - Feb 84 14. Sponsoring Agency Code TDC 4925
15. Supplementary Notes The main report is presented in two volumes.	16 TDC Project Officer Wayne Rowan

17. Abstract

An investigation was carried out to examine the effectiveness of lignin cellulose cement (trade name Fujibeton B), flyash, and flyash combined with cement as soil treatment agents. An extensive laboratory testing program was carried out on samples of fine grained soils treated with these agents. The soils comprised clayey, silty and sandy materials taken from five sites in southern Alberta, Canada, where problems related to soil volume change potential or frost susceptibility were known to exist. Laboratory testing included moisture density relations, index tests, strength tests and durability tests. The tests results indicate that Fujibeton B and flyash combined with cement can significantly improve the properties of fine sand, silt and clay relevant to earthworks design, whereas, the flyash examined (Battle River, Class F Ash) as sole treatment agent can improve soil properties only to a limited extent, if at all. A comparison of the effectiveness of the products identified above and cement or lime was developed from a review of the literature. Cost effectiveness data for the use of the soil treatment agents investigated was developed. The report concludes that Fujibeton B is effective as a stabilizer for silty and sandy soils and as a modifier of clayey soils and can be economical for use in earthworks construction where gravel and asphalt haulage distances are significant. Flyash combined with cement is effective as a stabilizer or modifier of silty and sandy soils but was not found to be economical for the case of secondary highway construction considered in this report.

18. Key Words Soil Stabilization, Soil Modification, Soil Cement, Flyash, Lignin Cellulose, Earthworks Design, Frost Susceptibility, Volume Change Potential.	19. Distribution Statement A limited number of copies are available from the Transportation Development Centre.

20. Security Classification (of this report) Unclassified	21. Security Classification (of this page) Unclassified	22. No. of Pages 20	23. Price

TDC/CDT 79-005

FORMULE DE DOCUMENTATION POUR RAPPORT

1. Nº du rapport Transports Canada
TP 5288E

2. Nº de l'étude — CDT
4925, 4926

3. Nº de catalogue du destinataire

4. Titre et sous-titre
Laboratory Evaluation of Flyash Cement and Lignin
Cellulose Cement as Soil Stabilizers
Summary Report

5. Date du rapport
mars 1984

6. Nº du rapport de l'organisme exécutant
0304-31264-002

7. Auteur(s)
M.D. Graham and C.B. Dawley

8. Nº de dossier Transports Canada
D1465-413

9. Nom et adresse de l'organisme executant
EBA Engineering Consultants Ltd.
7175 - 12 Street S.E.
Calgary, Alberta
T2H 2S6

10. Nº de dossier — ASC
14SD.T8200-2-2582

11. Nº de contrat — ASC ou Transports Canada
1SD83-00026

12. Nom et adresse de l'organisme parrain
Centre de développement des transports, Suite 2421
1000 ouest, rue Sherbrooke
Montréal, Québec H3A 2R3

Approvisionnements et services Canada
88 rue Metcalfe
Ottawa, Ontario K1A 0B5

13. Genre de rapport et période visée
Sommaire; juin 83 - fév. 84

14. Code de l'organisme parrain
CDT 4925, 4926

15. Remarques additionnelles
Le rapport final est présenté en deux volumes.

16. Agent de projet — CDT
W.G. Rowan

17. Résumé

Ce rapport rend compte des résultats d'une étude visant à déterminer l'efficacité des traitements de stabilisation des sols à l'aide de liants nouveaux, notamment un mélange ciment-lignocellulose (marque de fabrique: Fujibeton B), un mélange ciment-cendres volantes et des cendres volantes utilisées seules. Pour cela, un échantillonnage de sols à granulométrie fine a été traité au moyen de ces liants et soumis à un programme exhaustif d'essais et d'analyses en laboratoire. Les sols échantillonnés étaient des sols argileux, silteux et sablonneux, provenant de cinq sites différents du sud de l'Alberta, caractérisés par des problèmes d'instabilité volumique ou de sensibilité au gel. Ces essais en laboratoire avaient pour objet la détermination des relations teneur en eau-densité, des indices de plasticité, des indices de portance et de la durabilité. Les résultats indiquent que le Fujibeton B et les mélanges ciment-cendres volantes peuvent améliorer considérablement les propriétés géotechniques des sols sablonneux, silteux et argileux tandis que les cendres volantes de Battle River, classe F, utilisées seules, n'apportent qu'un gain tout à fait relatif, si gain il y a. Le rapport compare l'efficacité des produits nouveaux ci-dessus à celle du ciment et de la chaux utilisés seuls, se basant pour cela sur les résultants d'une recherche documentaire. Cette comparaison est suivie d'une étude économique de l'utilisation des divers agents de traitement considérés. Cette étude conclut que le Fujibeton B est un agent de stabilisation efficace des sols silteux et sablonneux et une bon correcteur des propriétés des sols argileux, et que son emploi est économiquement justifié lorsque les distances de transport des graviers et bitumes utilisables à sa place sont importantes. Les mélanges ciment-cendres volantes sont efficaces dans le cas des sols silteux et sablonneux mais leur emploi n'est pas rentable dans l'optique des constructions de routes secondaires envisagées ici.

18. Mots-clés
Stabilisation des sols, modification des sols, sol-ciment, centres volantes, lignocellulose, terrassements, sensibilité au gel, instabilité volumique

19. Diffusion
Le Centre de développement des transports dispose d'un nombre limité d'exemplaires

20. Classification de sécurité (de ce rapport)
non-classifié

21. Classification de sécurité (de cette page)
non-classifiée

22. Nombre de pages
20

23. Prix
--

CDT TDC 79-005

SUMMARY

The construction of embankments or subgrades for streets, highways, railways, airport runways and other related facilities usually necessitates the use of locally available soils, often clays, silts or sands or heterogeneous mixtures of two or more of these soil types. Special design considerations may be required for some fine grained soils that exhibit swelling and shrinkage characteristics through wetting and drying and/or that are susceptible to frost action.

In the study reported herein, EBA Engineering Consultants Ltd. has carried out a series of laboratory tests on fine grained soils from Southern Alberta treated with commercially available products intended to improve the soil performance for civil engineering design. The purpose of the laboratory evaluation is to quantify the suitability, effectiveness and economics of using flyash cement and lignin cellulose cement (trade name Fujibeton B) as soil treatment agents.

Laboratory testing data, presented in the report, includes grain size analyses, index properties, moisture density relations, freeze-thaw durability test results, wet-dry durability test results, California Bearing Ratio test results and unconfined compressive strengths.

The overall objective of this project is to evaluate the cost effectiveness of construction of highways, railways and airport embankments, pavements and other earthworks utilizing these products. Historically, stabilization of such soils has involved Portland cement or lime, both manufactured products. Hence cost effectiveness has been evaluated relative to construction with Portland cement and lime.

For the purpose of this report a detailed cost analysis has been made for construction of a typical secondary highway in Alberta. Maintenance costs have not been quantified. General comments regarding cost effectiveness of soil treatment agents utilized in other projects are made on the basis of the detailed cost analysis after consideration of the relative volumes of imported materials required for construction.

The study concludes that;

a) Fujibeton B is suitable, effective and sometimes economical for use as a stabilizer of silty and sandy soils and for use as a modifier of clayey soils. The use of Fujibeton B can be economical for construction of secondary highways over silty subgrades where gravel and asphalt haulage distances exceed about 60 km, and for general use in temporary works over sandy, silty or clayey subgrades. The use of Fujibeton B would likely be economical for

construction of heavier pavements and embankments. Costs have not been quantified for these items however costs could be calculated from data presented in the main report.

b) Flyash and cement combined are suitable, effective but apparently not economical for use as stabilizers or modifiers of silty and sandy soils for the scenarios considered in this report.

c) Flyash alone is occasionally suitable and effective but not economical for use as a modifier of silty soils.

d) The treatment of clayey soils using flyash alone is not effective.

e) The treatment of clayey soils using flyash combined with cement does not appear to be economical for the cases considered in this report.

TABLE OF CONTENTS

			Page No.
SUMMARY			
1.0		INTRODUCTION	1
2.0		LABORATORY TESTING PROGRAM	2
	2.1	General	2
	2.2	Sample Sources	2
	2.3	Investigative Tests	3
3.0		LITERATURE REVIEW	3
4.0		COMPARISON OF SOIL IMPROVEMENT AGENTS	5
	4.1	Effectiveness of Soil Improvement Agents	5
	4.2	Cost Aspects	6
REFERENCES			

1.0 INTRODUCTION

The construction of embankments or subgrades for streets, highways, airport runways and other related facilities, usually necessitates the use of locally available soils such as clay, silt, sand or heterogeneous mixtures of two or more of these soil types.

Characteristically, project costs escalate drastically when such soils are utilized in works which include a structurally designed pavement component such as an airport runway or a highway.

Historically, attempts have been made to stabilize such soils, utilizing, for example, Portland cement or lime. Both these materials are manufactured products which require consumption of non-renewable natural resources such as natural gas in their manufacture.

In more recent times, materials which have been previously viewed as either "waste" or "by-products" of primary manufacture have been recognized for their potential in certain uses in respect to stabilization or modification of fine grained soils used in embankment construction. Two of these are:

- flyash which is a residual product at coal-fired thermal electric plants
- lignin cellulose which is a by-product of pulp and paper manufacture.

These products, as an additive to Portland cement, reduce the volume of cement required to prepare soil cement mixes in some cases and can improve the quality of soil cement where it is used to stabilize poor quality soils. Flyash is also promoted for use as a soil treatment agent without prior mixing with cement.

This summary report presents the results of an analytical program to determine the ability of these soil treatment agents to cost effectively modify certain properties of fine grained soils.

The flyash tested comprised Class F flyash supplied from the Battle River Power Plant, Forestburg Alberta by Pozzolanic International Ltd. The lignin cellulose cement stabilizer tested comprised "Fujibeton B" which is cement with lignin cellulose and other chemical additives. The Fujibeton was supplied by R.J. MacMillan Enterprises Ltd., Richmond, British Columbia.

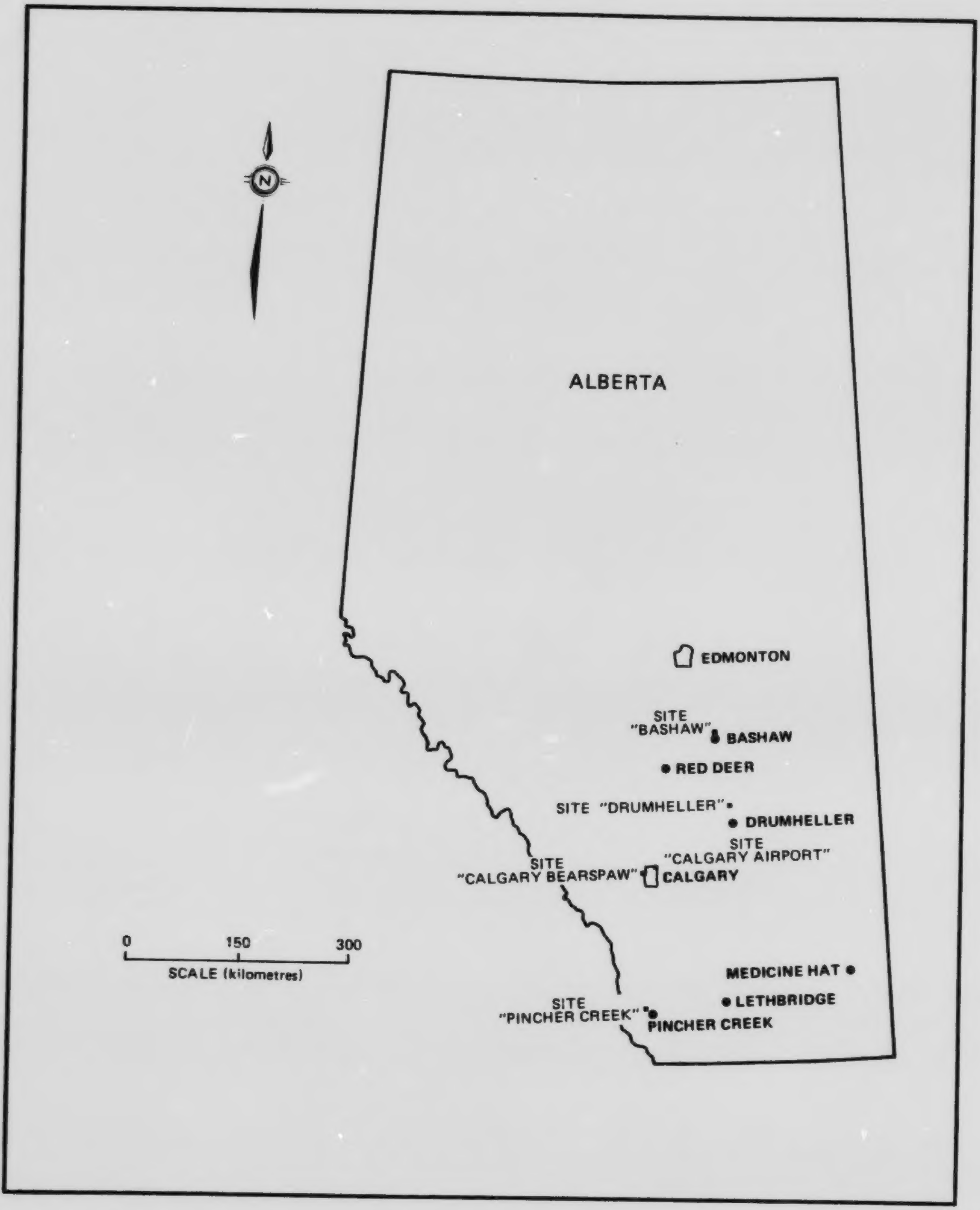

ALBERTA
EDMONTON
SITE "BASHAW"
BASHAW
RED DEER
SITE "DRUMHELLER"
DRUMHELLER
SITE "CALGARY AIRPORT"
SITE "CALGARY BEARSPAW"
CALGARY
MEDICINE HAT
LETHBRIDGE
SITE "PINCHER CREEK"
PINCHER CREEK
N
0
150
300
SCALE (kilometres)

FIGURE 1 LOCATION OF SITES EXAMINED

2.0 LABORATORY TESTING PROGRAM

2.1 GENERAL

Samples of frost susceptible fine grained soil and soil of high volume change potential were obtained from five known problem areas in Southern Alberta.

The soils were first subjected to a series of control tests to determine the natural soil characteristics relevant to the design of soil structures. The soils were then mixed with various quantities of flyash, flyash and cement, or Fujibeton 'B' stabilizer and retested. A more comprehensive testing program was carried out on soil samples taken from two of the sites.

In general the appropriate ASTM designated methods (Ref. 1) were followed except as otherwise noted on the laboratory test result sheets.

2.2 SAMPLE SOURCES

Site selection was based on the significant frost susceptibility or high volume change potential of the soil known to exist at each site.

The sites examined were:

- Bearspaw Water Treatment Plant, Northwest Calgary
- Calgary International Airport, Northeast Calgary
- Road Easement on Highway 56 at Morrin, about 20 km North of Drumheller
- Road Easement on Highway 3 near Cowley, about 10 km West of Pincher Creek
- Road Easement on Highway 21, about 5 km North of Bashaw.

In this report the sites are referred to as Calgary Bearspaw, Calgary Airport, Drumheller, Pincher Creek and Bashaw.

The sites are located on Figure 1. In Table 1 basic gradation and plasticity characteristics of these soils are summarized.

TABLE 1

AVERAGE CLASSIFICATION CHARACTERISTICS OF THE TEST SOILS

SITE	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	PLASTICITY INDEX (%)	GRADATION SAND (%)	SILT (%)	CLAY (%)	AASHO CLASSIFICATION (REF. 2)
Calgary Bearspaw	25	18	7	22	53	25	A-4
Calgary Airport	30	18	12	27	48	25	A-6
Pincher Creek	52	25	27	10	45	45	A-7-6
Drumheller	75 - 90	45 - 50	30 - 40	1	30	69	A-7-5
Bashaw	---	---	NP	91	7	2	A-3

2.3 INVESTIGATIVE TESTS

A total of ten to twelve soil stabilizer mixtures were tested from each of the five sites during Phase I of the laboratory testing program; five or six were stabilized with Fujibeton B, four or five were stabilized with flyash alone and one was stabilized with flyash and cement combined. A further eight soil stabilizer mixtures were tested from two of the sites (Pincher Creek and Calgary Bearspaw) during Phase II of the laboratory testing program; these eight mixtures were stabilized using flyash and cement combined.

The laboratory tests comprised grain size analyses, Atterberg limit determinations, moisture density relations, freeze-thaw and wet-dry durability tests, California Bearing Ratio tests and unconfined compressive strength tests.

3.0 LITERATURE REVIEW

A significant quantity of research work has been performed to date in the fields of soil stabilization and soil modification in order to examine the effectiveness of cement or lime as soil improvement agents. Some published work is available which addresses the use of flyash as a soil improvement agent or as a replacement for bulk soil fill. The information available pertaining to usage of Fujibeton is primarily of the vested interest type and is published through the product supplier.

This review summarizes some of the published information available for soil improvement agents.

Where the soil cement mixture is hardened to a low strength concrete like material the improvement process is known as soil stabilization. As an alternative to soil stabilization soils can be improved through modification of the soil plasticity and moisture requirements for field compaction. Field modified soils are not necessarily cemented although in the short term localized cementation of soils can occur.

Stabilized base construction is dependant upon several factors including granularity of soil, weathering environment, traffic loading and required construction design life. Experimental and empirical methods have been developed which allow the design of pavement structures.

In general the design of pavement structures incorporating soil cement requires that the soil cement base be of a minimum compressive strength or be of sufficient durability so that satisfactory performance is obtained throughout the design life.

Cement is widely accepted for use as a stabilizer for course grained soils such as sands and gravels. These stabilized materials then form base for further construction. However, finer grained soils require higher dosage rates of cement in order to obtain a stabilized base, which can have a significant economic impact upon the road design. Normally, treated clayey soils are modified using a relatively small stabilizer dosage rate rather than adopting an expensive stabilization procedure.

Lime is generally significantly less expensive than cement and is a proven modifier of clay soils with respect to soil plasticity, field moisture control, strength and permeability. Lime modified soils are not intended to meet the durability requirements for a stabilized base.

The use of flyash in earthworks has been associated with cement or lime improved soils. Flyash has been used alone on a small minority of earthwork projects (Ref. 9). Recently, however, the flyash industry has been promoting further usage of the product and one market area pursued is that of flyash acting alone as a soil improvement agent.

Another product on the market, Fujibeton B, contains, lignin cellulose other chemicals and normal portland cement. The suitability of this material for use as a soil improvement agent is detailed in the suppliers promotional literature. However, as the product is new in North America there does not appear to be published independant research work available which elaborates upon the promotional literature.

Design considerations for improvement of soil are numerous, including for example, type of earth structure, required design life, static and dynamic loadings, weathering effects and selection of an appropriate improvement agent.

The Shell (1978) design method (Ref. 8) provides data on the thickness of the surface course, the base course and the subbase course for a given road design situation. The Shell method is used in this report as a reference design method. Several other design techniques could be used and comparisons made between the various design methods. However, this design assessment is considered beyond the scope of this report.

Guidance in the selection of an appropriate soil treatment agent is provided by Brabston 1974 (Ref. 3) and Kedzi 1979 (Ref. 3).

Extensive guidance is provided by the Portland Cement Association (Ref. 7) for the selection of a suitable design cement dosage rate for treatment of soil. Selection of a suitable design lime dosage rate can be made from a review of publications by Brandl 1981 and Lees et al 1982 (Ref. 4 and 6).

4.0 COMPARISON OF SOIL IMPROVEMENT AGENTS

4.1 EFFECTIVENESS OF SOIL IMPROVEMENT AGENTS

In making a general comparison of the performance of the various soil treatment agents available on the market it is important to realize that the chemical composition of a soil may influence the effectiveness of one product but not another and that the intended use of the earthworks and potential weathering actions can also significantly influence the selection of a treatment agent.

In comparison with routinely used cement and lime treatment agents, significant dosage rates of flyash are required to achieve the same modifying effect if indeed it is possible to achieve the same modifying effect.

The use of Battle River flyash in combination with normal Portland Cement can allow the stabilization of sandy or silty soils and the modification of clayey soils. It is considered that the pozzolanic activity of the flyash can be efficiently utilized where silty and sandy soils are to be stabilized, but not for stabilization of clayey soils.

The stabilized silty material from Calgary Bearspaw site showed a strength gain proportional to the cement dosage and to a lesser extent a strength gain dependant on the flyash dosage whereas stabilized clayey material from Pincher Creek site did not increase in strength for a wide range of flyash dosage rates.

Modification of soil properties using a combination of cement and flyash is primarily dependant upon the cement dosage rate and to a small extent upon the flyash dosage rate. For example clayey soil from Pincher Creek was modified from the natural state to a nonplastic condition utilizing 3% cement combined with 12% flyash by weight of dry soil, whereas the plasticity index of the soil was only slightly reduced from the natural value of about 28 to about 17 when a dosage rate of 15% flyash by weight of dry soil was used. Modification of soil utilizing such a high dosage rate (15 to 16%) of the treatment agent is unnecessary. On the basis of Brandl 1981 (Ref. 4) a dosage rate of about 5% lime can significantly reduce the plasticity index of a clayey soil.

The results of this laboratory study for Fujibeton B can be compared with typical results expected for cement treated soils provided by the

TABLE 2

FUJIBETON, B AND CEMENT DOSAGE RATES FOR DURABILITY PERFORMANCE

SAMPLE SITE	SOIL DESCRIPTION (AASHO CLASSIFICATION)	FUJIBETON CONTENT[1] (% BY WEIGHT) WET-DRY DURABILITY	FUJIBETON CONTENT[1] (% BY WEIGHT) FREEZE-THAW DURABILITY	PORTLAND CEMENT CONTENT[2] (% BY WEIGHT)
Calgary Bearspaw	Silt (A-4)	8	10	10
Calgary Airport	Silt (A-6)	9	N/A	12
Bashaw	Sand (A-3)	6	6	9

Notes: 1. As determined in the lab program presented herein.
2. As per Portland Cement Association (Ref. 14).

Portland Cement Association (Ref. 7). The Fujibeton material appears to perform at least as well as the performance which could be anticipated for cement. For the silty and sandy soils examined it is possible that the Fujibeton material performed better than would be expected for cement (consider for example the performance record in Table 2). However, unless comparison tests are made on the same soil materials it would be unreasonable to conclude that Fujibeton is definitely a superior soil treatment agent than cement.

The clayey soils examined could be modified to a nonplastic state utilizing 6% or less dosage rate of Fujibeton based upon tests carried out for this program. This dosage rate is comparable with typical cement or lime dosage rates in the range 5% to 8% (Ref. 4 and 7) which may be selected for these soils in order to reduce soil plasticity. At these dosage rates cement or lime modified clays may not be completely nonplastic but the volume change potential of the soils would be significantly reduced. Again it appears that the Fujibeton material is slightly more efficient in terms of dosage requirement for treatment of soils. However, it should be stressed that as no reference tests were carried out on soils tested using cement or lime, a general conclusion to this effect cannot be made.

In summary of the above

i) the performance of flyash as a treatment agent is not as efficient as cement or lime, and in some cases should not be used at all as a treatment agent.

ii) the performance of flyash and cement combined as a treatment agent is generally less efficient than cement or lime treatment.

iii) the performance of Fujibeton appears to be slightly superior to that of cement or lime but it is stressed that this comparison is made by review of the literature and no direct comparison tests have been made in this program.

This study has indicated that Fujibeton is suitable for use as a modifier of clayey soils and a stabilizer of silty and sandy soils and that Battle River flyash can be suitable for use as a modifier of silty soils.

4.2 COST ASPECTS

After discussion with Alberta Transportation and based on the supply costs of Fujibeton B, cement and flyash, cost estimates were prepared for secondary road construction.

Based on this cost analysis for road construction it was found that:

i) Normal road design methods are appropriate over silty subgrades for gravel and asphalt haulage distances of less than about 60 km. Beyond 60 km it appears to be more economical to design for a stabilized subgrade which meets long term durability requirements. If the road is to be designed for a short life or potential weathering action at the road site is slight then it could be economical to use a modified road design incorporating Fujibeton treatment of the subgrade.

ii) Normal road design methods are appropriate over uniform fine grained sandy subgrades for gravel and asphalt haulage distances of less than about 40 km.

iii) Normal road design methods are appropriate over clayey subgrades where initial capital cost of road construction is to be minimized. It would be possible to justify the use of lime or Fujibeton as a soil modifier in order to reduce maintainance costs. Maintenance costs have not been quantified.

iv) Fujibeton appears to be more cost effective as a soil treatment agent than flyash and cement combined for sandy and silty soils.

v) Lime appears to be more cost effective than Fujibeton as a modifier of clayey soils.

Other soil structures such as airport pavements or large embankments could be examined and the cost effectiveness of treatment agents could be identified. It is considered, however, that the general conclusions reached through the cost effectiveness analysis carried out for this program may be extended to other soil structures, with due consideration for additional pavement structure thickness and fill volume.

REFERENCES

1. American Society for Testing and Materials "Annual Book of ASTM Standards" (1983).

2. American Association of State Highway Official "Recommended Practice for the Classification of Soils and Soil Aggregate Mixtures for Highway Construction Purposes" M 145 - 73.

3. Brabston W.N. et al. (1974) "Soil Stabilization for Roads and Airfields in the Theater of Operations". Miscellaneous Paper S-74-23, U.S. Army Waterways Experiment Station.

4. Brandl H. (1981) "Alteration of Soil Parameters by Stabilization with Lime". Proceedings Int. Conf. Soil Mech. & Found. Eng.

5. Kezdi A. (1979) "Stabilized Earth Roads" Elsevier Scientific Publishing Company.

6. Lees G., Abdelkater M.O. and Hamdani S.K. (1982) "Effect of the Clay Fraction on Some Mechanical Properties of Lime Soil Mixtures" Journal of Institution of Highway Engineers.

7. Portland Cement Association (1971) "Soil-Cement Laboratory Handbook".

8. Shell Oil Company (1978) "Shell Pavement Design Manual".

9. U.S. Department of Transportation "Flyash A Highway construction Material" Implementation Package 76-16.

Centre de développement
des transports (CDT)

Complexe Guy Favreau
200 ouest boul. Dorchester
Suite 601, tour ouest
Montréal, Québec
H2Z 1X4

Transportation
Development Centre (TDC)

Complexe Guy Favreau
200 Dorchester Blvd. West
Suite 601, West Tower
Montreal, Quebec
H2Z 1X4

Number/
Numéro

2

LABORATORY EVALUATION OF FLYASH CEMENT AND LIGNIN CELLULOSE CEMENT AS SOIL STABILIZERS

VOLUME I OF II

Prepared for:
TRANSPORTATION DEVELOPMENT CENTRE

MARCH 1984

CA1
DTC 845
84
L12
v.1
c.2

EBA Engineering Consultants Ltd.
MATERIALS ENGINEERING GROUP

85-2362/

314-1264-02

TP 5287 E

LABORATORY EVALUATION OF FLYASH CEMENT AND LIGNIN CELLULOSE CEMENT AS SOIL STABILIZERS

VOLUME I OF II

Library and Information Centre
Centre de Documentation (GSL)
RECEIVED - REÇU LE
SEP 10 1984
Government Publication Officielle
Transport Canada / Transports Canada

Prepared for:

TRANSPORTATION DEVELOPMENT CENTRE

by:

MICHAEL D. GRAHAM, P.ENG. AND C.B. DAWLEY, P.ENG.
EBA ENGINEERING CONSULTANTS LTD.

MARCH, 1984

314-1264-02

"The contents of this report reflect the views of the contractor and not necessarily the official views or policies of the Transportation Development Centre".

PROJECT TEAM

The project team for EBA Engineering Consultants Ltd. comprised:

Mr. C.B. Dawley
Mr. N.R. MacLeod
Mr. M.D. Graham
Ms. E. Dynka
Mr. N. Foofat
Ms. D. Corbett
Ms. M. Nowakowski
and others

REPORT DOCUMENTATION FORM

1. Transport Canada Report No.
TP 5287E

2. TDC Project No
4925,4926

3. Recipient's Catalogue No

4. Title and Subtitle
Laboratory evaluation of flyash cement and lignin cellulose cement as soil stabilizers (2 volumes)

5. Report Date
March, 1984

6. Performing Organization Report No
0304-31264-002

7. Author(s)
M.D. Graham and C.B. Dawley

8. Transport Canada File No
D1465-413

9. Performing Organization Name and Address
EBA Engineering Consultants Ltd.
7175 - 12 Street S.E.
Calgary, Alberta T2H 2S6

10. DSS File No
14SD.T8200-2-2582

11. DSS or Transport Canada Contract No
1SD83-00026

12. Sponsoring Agency Name and Address
Transportation Development Centre
1000 Sherbrooke Street West
Suite 2421
Montreal Quebec H3A 2R3

Supply & Services Canada
88 Metcalfe Street
Ottawa, Ontario
K1A 0B5

13. Type of Report and Period Covered
Final Jun 83 - Feb 84

14. Sponsoring Agency Code
TDC 4925

15. Supplementary Notes
Summary report (TP 5288) is available in English and in French.

16. TDC Project Officer
Wayne Rowan

17. Abstract

An investigation was carried out to examine the effectiveness of lignin cellulose cement (trade name Fujibeton B), flyash, and flyash combined with cement as soil treatment agents. An extensive laboratory testing program was carried out on samples of fine grained soils treated with these agents. The soils comprised clayey, silty and sandy materials taken from five sites in southern Alberta, Canada, where problems related to soil volume change potential or frost susceptibility were known to exist. Laboratory testing included moisture density relations, index tests, strength tests and durability tests. The tests results indicate that Fujibeton B and flyash combined with cement can significantly improve the properties of fine sand, silt and clay relevant to earthworks design, whereas, the flyash examined (Battle River, Class F Ash) as sole treatment agent can improve soil properties only to a limited extent, if at all. A comparison of the effectiveness of the products identified above and cement or lime was developed from a review of the literature. Cost effectiveness data for the use of the soil treatment agents investigated was developed. The report concludes that Fujibeton B is effective as a stabilizer for silty and sandy soils and as a modifier of clayey soils and can be economical for use in earthworks construction where gravel and asphalt haulage distances are significant. Flyash combined with cement is effective as a stabilizer or modifier of silty and sandy soils but was not found to be economical for the case of secondary highway construction considered in this report.

18. Key Words
Soil Stabilization, Soil Modification, Soil Cement, Flyash, Lignin Cellulose, Earthworks Design, Frost Susceptibility, Volume Change Potential.

19. Distribution Statement
A limited number of copies are available from the Transportation Development Centre.

20. Security Classification (of this report)
Unclassified

21. Security Classification (of this page)
Unclassified

22. No. of Pages

23. Price

TDC CDT 79-005

FORMULE DE DOCUMENTATION POUR RAPPORT

1. Nº du rapport Transports Canada: TP 5287E

2. Nº de l'étude — CDT: 4925, 4926

3. Nº de catalogue du destinataire

4. Titre et sous-titre

Laboratory Evaluation of Flyash Cement and Lignin
Cellulose Cement as Soil Stabilizers (2 Volumes)

5. Date du rapport: mars 1984

6. Nº du rapport de l'organisme exécutant: 0304-31264-002

7. Auteur(s): M.D. Graham and C.B. Dawley

8. Nº de dossier Transports Canada: D1465-413

9. Nom et adresse de l'organisme exécutant

EBA Engineering Consultants Ltd.
7175 - 12 Street S.E.
Calgary, Alberta
T2H 2S6

10. Nº de dossier — ASC: 14SD.T8200-2-2582

11. Nº de contrat — ASC ou Transports Canada: 1SD83-00026

12. Nom et adresse de l'organisme parrain

Centre de développement des
transports, Suite 2421
1000 ouest, rue Sherbrooke
Montréal, Québec H3A 2R3

Approvisionnements et services
Canada
88 rue Metcalfe
Ottawa, Ontario K1A 0B5

13. Genre de rapport et période visée: Final; juin 83 - fév. 84

14. Code de l'organisme parrain: CDT 4925, 4926

15. Remarques additionnelles

Le rapport sommaire (TP 5288) est disponible en français et en anglais.

16. Agent de projet — CDT: W.G. Rowan

17. Résumé

Ce rapport rend compte des résultats d'une étude visant à déterminer l'efficacité des traitements de stabilisation des sols à l'aide de liants nouveaux, notamment un mélange ciment-lignocellulose (marque de fabrique: Fujibeton B), un mélange ciment-cendres volantes et des cendres volantes utilisées seules. Pour cela, un échantillonnage de sols à granulométrie fine a été traité au moyen de ces liants et soumis à un programme exhaustif d'essais et d'analyses en laboratoire. Les sols échantillonnés étaient des sols argileux, silteux et sablonneux, provenant de cinq sites différents du sud de l'Alberta, caractérisés par des problèmes d'instabilité volumique ou de sensibilité au gel. Ces essais en laboratoire avaient pour objet la détermination des relations teneur en eau-densité, des indices de plasticité, des indices de portance et de la durabilité. Les résultats indiquent que le Fujibeton B et les mélanges ciment-cendres volantes peuvent améliorer considérablement les propriétés géotechniques des sols sablonneux, silteux et argileux tandis que les cendres volantes de Battle River, classe F, utilisées seules, n'apportent qu'un gain tout à fait relatif, si gain il y a. Le rapport compare l'efficacité des produits nouveaux ci-dessus à celle du ciment et de la chaux utilisés seuls, se basant pour cela sur les résultants d'une recherche documentaire. Cette comparaison est suivie d'une étude économique de l'utilisation des divers agents de traitement considérés. Cette étude conclut que le Fujibeton B est un agent de stabilisation efficace des sols silteux et sablonneux et une bon correcteur des propriétés des sols argileux, et que son emploi est économiquement justifié lorsque les distances de transport des graviers et bitumes utilisables à sa place sont importantes. Les mélanges ciment-cendres volantes sont efficaces dans le cas des sols silteux et sablonneux mais leur emploi n'est pas rentable dans l'optique des constructions de routes secondaires envisagées ici.

18. Mots-clés: Stabilisation des sols, modification des sols, sol-ciment, centres volantes, lignocellulose, terrassements, sensibilité au gel, instabilité volumique

19. Diffusion

Le Centre de développement des transports dispose d'un nombre limité d'exemplaires

20. Classification de sécurité (de ce rapport): non-classifié

21. Classification de sécurité (de cette page): non-classifiée

22. Nombre de pages

23. Prix: --

TABLE OF CONTENTS

Page No.

SUMMARY

1.0 INTRODUCTION 1

2.0 LABORATORY TESTING PROGRAM 3
- 2.1 Sample Sources 3
- 2.2 General Program 4
- 2.3 Control Tests 5
- 2.4 Investigative Tests 5

3.0 LABORATORY TEST RESULTS 5
- 3.1 Calgary Bearspaw 5
- 3.1.1 Changes In Plasticity 6
- 3.1.2 Improved CBR 6
- 3.1.2 Improved Durability 7
- 3.2 Calgary Airport 8
- 3.2.1 Changes In Plasticity 8
- 3.2.2 Improved CBR 9
- 3.2.3 Improved Durability 9
- 3.3 Pincher Creek 10
- 3.3.1 Changes In Plasticity 10
- 3.3.2 Improved CBR 11
- 3.3.3 Improved Durability 11
- 3.4 Drumheller 11
- 3.4.1 Changes In Plasticity 12
- 3.4.2 Improved CBR 12

TABLE OF CONTENTS (continued)

Page No.

3.4.3 Improved Durability 13
3.5 Bashaw 13
3.5.1 Improved Workability 13
3.5.2 Improved CBR 14
3.5.3 Improved Durability 15

4.0 LITERATURE REVIEW 15
4.1 General 15
4.2 Cement and Lime 16
4.3 Flyash 18
4.4 Chemicals 19
4.5 Design of Pavements 19

5.0 ASSESSMENT OF SOIL IMPROVEMENT AGENTS 21
5.1 Fujibeton B 21
5.2 Flyash 24
5.3 Flyash and Cement 26

6.0 COMPARISON OF SOIL IMPROVEMENT AGENTS 27
6.1 Effectiveness Of Soil Improvement Agents 27
6.2 Cost Aspects 30
6.2.1 Comparison For Road Construction 30
6.2.2 Evaluation 31

TABLE OF CONTENTS (continued)

		Page No.
7.0	CONCLUSIONS	33
7.1	Potential Economic Benefits	33
7.2	Further Research Topics	34

REFERENCES
TABLES
FIGURES

x

LABORATORY EVALUATION OF FLYASH CEMENT AND LIGNIN CELLULOSE CEMENT AS SOIL STABILIZERS

1.0 INTRODUCTION

The construction of embankments or subgrades for streets, highways, airport runways and other related facilities, usually necessitates the use of locally available soils. Fine grained soils, including silt and clay are frequently associated with construction and maintenance problems. These include:

o workability at its natural moisture content
o frost susceptibility
o swelling and shrinkage through wetting and drying.

Special design considerations and construction practices are often required when soils, which exhibit the foregoing characteristics, are encountered. Characteristically, materials, construction and maintenance costs escalate drastically when such soils are utilized in works which include a structurally designed pavement component such as an airport runway or a highway.

Historically, Portland cement or lime has been made to stabilize such soils. Both these materials are manufactured products which require consumption of non-renewable natural resources such as natural gas in their manufacture.

More recently, some "waste" or "by-products" of primary manufacturing have been recognized for their potential, in certain uses, to improve the behaviours of fine grained soils used in embankment construction. Two of these are:

- flyash which is residual product at coal-fired thermal electric plants
- lignin cellulose which is a by-product of pulp and paper manufacture.

These products, as an additive to Portland cement, reduce the volume of cement required to prepare soil cement mixes in some cases and can improve the quality of soil cement. Flyash is also promoted for use as a soil treatment agent without mixing with cement.

This report presents the results of an analytical program to determine the ability of these soil treatment agents to cost effectively modify certain properties of fine grained soils. The flyash tested comprised Class F flyash obtained from the Battle River Power Plant, Forestburg Alberta by Pozzolanic International Ltd. The lignin cellulose cement stabilizer tested comprised "Fujibeton B" which is a blend of cement, lignin cellulose and other products. The Fujibeton was supplied by R.J. MacMillan Enterprises Ltd., Richmond, British Columbia.

Volume I of this report presents the text and graphically summarizes the laboratory test results and cost effectiveness data. Volume II which is provided as documentation of the study presents detailed laboratory data sheets for each test.

2.0 LABORATORY TESTING PROGRAM

2.1 SAMPLE SOURCES

Samples of frost susceptible fine grained soil and soil of high volume change potential were obtained from five known problem areas in Southern Alberta. The sites, located as shown on Figure 1, were:

- Bearspaw Water Treatment Plant, Northwest Calgary
- Calgary International Airport, Northeast Calgary
- Road easement on Highway 3 near Cowley, about 10 km West of Pincher Creek
- Road easement on Highway 56 at Morrin, about 20 km North of Drumheller
- Road easement on Highway 21, about 5 km North of Bashaw.

In this report the sites are referred to as Calgary Bearspaw, Calgary Airport, Drumheller, Pincher Creek and Bashaw.

Approximately 500 kg of sample was obtained at each site from a depth of about 0.5 m to 1.0 m below ground level. These samples were utilized in Phase I of the laboratory testing program. Additional material was obtained from Pincher Creek and Calgary Bearspaw for utilization in Phase II of the laboratory testing program.

The soils taken from Calgary Bearspaw and Calgary Airport are silty and frost susceptible. The soil taken from Drumheller has a very high volume change potential. The soil from Pincher Creek is both frost susceptible and has a high volume change potential. The soil from Bashaw is frost susceptible and due to the uniform grading of the material would be difficult to utilize in field earthworks. In Table 1, basic gradation and plasticity characteristics of these soils are summarized. A plasticity chart is presented on Figure 2.

2.2 GENERAL PROGRAM

The soils were first subjected to a series of control tests to determine the natural soil characteristics relevant to the design of soil structures. The soils were then mixed with various quantities of flyash, flyash and cement, or lignin cellulose cement stabilizer and retested. The initial control testing and investigative work is designated Phase I of the laboratory testing program.

A more comprehensive testing program was carried out on samples taken from two of the sites using flyash and cement as the soil stabilizing agents. This supplemental testing is designated Phase II of the laboratory testing program.

The detailed results of all laboratory tests are presented in Volume II of this report. Summarized results are presented on Figures 2 to 37 in this volume of the report. Details of the soils examined, testing methodology and the summarized results are discussed below.

Laboratory test procedures are described in Appendix A, Volume II. In general, the appropriate ASTM designated methods (Ref. 1) were followed except as otherwise noted on the laboratory test result sheets.

2.3. CONTROL TESTS

In order to establish the natural or unmodified characteristics of the soils the testing program outlined in Table 2 was performed.

2.4 INVESTIGATIVE TESTS

A total of ten to twelve soil stabilizer mixtures were tested for each of the five sites during Phase I of the laboratory testing program; five or six were stabilized with Fujibeton B, four or five were stabilized with flyash alone and one was stabilized with flyash and cement combined. Phase I testing is outlined in Table 3. A further eight soil stabilizer mixtures were tested from two of the sites (Pincher Creek and Calgary Bearspaw) during Phase II of the laboratory testing program; these eight mixtures were stabilized using flyash and cement combined. The Phase II testing program is outlined in Table 4.

The stabilizer dosage rates utilized for tests are given in Table 5.

3.0 LABORATORY TEST RESULTS

3.1 CALGARY BEARSPAW

The soil from Calgary Bearspaw is a clayey sandy silt. Index characteristics are presented in Table 1. This soil would be classified as being of very high frost susceptibility (Ref. 20) and as having a low volume change potential (Ref. 5).

Two phases of laboratory testing were carried out on soil samples taken from the Calgary Bearspaw site. Phase I concentrated upon the performance of lignin cellulose cement (Fujibeton) and flyash as stabilizers; whereas, Phase II concentrated upon the performance of flyash in combination with cement as a stabilizing agent.

The results of the control laboratory tests are summarized on Figures 3, 4 and 5. The results of the investigative tests are summarized on Figures 6 through 12. Detailed test results are presented in Volume II of this report.

3.1.1 Changes In Plasticity

The variation of soil plasticity with stabilizer dosage rate is shown on Figure 6. The soil stabilizer mixture is nonplastic 24 hours after mixing if at least 2% by weight of Fujibeton or 2% by weight of Portland cement is utilized as the stabilizing agent.

Figure 6 shows that the flyash does not influence the plasticity index of the soil as significantly as the Fujibeton. More than 10% by weight of flyash was required to reduce the plasticity index of the soil. Furthermore, the flyash did not produce a nonplastic soil stabilizer mixture at dosage rates of 16%.

3.1.2 Improved CBR

The addition of a stabilizing agent increases the strength of the compacted soil mixture. The California Bearing Ratio (CBR) of samples which contain at least 4% Fujibeton and have cured for seven days was between 20 and 100 times the CBR obtained for untreated soil (see Figure 7).

Samples stabilized with flyash alone did not exhibit the same degree of strength increase nor was the strength increase proportional to the flyash addition rate. As shown on Figure 8, the increased CBR value was generally variable from negligible to about 2.5 times the untreated CBR value. However, one specimen (13% flyash dosage rate) did show a strength increase to about 25 times the CBR for an untreated specimen compacted at the same moisture content.

The increase in strength obtained through utilization of cement and flyash combined is shown on Figure 9. It is apparent that the strength increase is dependant on primarily the cement content of the mix and to a lesser extent the flyash content of the mix. Increases in CBR value up to about 20 times that for an untreated soil specimen compacted at the same moisture content were obtained for specimens if 3% to 4% cement together with 7% to 9% flyash were utilized to stabilize the soil mixtures.

3.1.2 Improved Durability

The performance of compacted soil stabilizer mixtures during freeze-thaw and wet-dry durability tests are presented on Figures 10 and 11. About 10% Fujibeton is required to meet the Portland Cement Association (PCA) recommended guidelines (Ref. 14) for cement stabilized soil durability losses. For the dosage rates selected, the cement and flyash stabilized soils did not meet the PCA guidelines. It should be noted, however, that a dosage rate of 4% cement combined with 9% flyash was not exceeded and the losses noted at this dosage are comparable to those noted for a 4% Fujibeton dosage rate.

Unconfined compressive strength was measured after the full cycle of durability testing was completed. The strengths for samples stabilized with Fujibeton vary between about 1 MPa and 6 MPa dependant upon stabilizer dosage rate and the type of durability test (see Figure 12). Generally lower compressive strength results from freeze-thaw durability testing than from wet-dry durability testing.

3.2 CALGARY AIRPORT

The soil sampled at the Calgary Airport is a clayey sandy silt. Index characteristics are presented in Table 1. This soil would have a very high frost susceptibility and a low volume change potential.

One phase of laboratory testing was carried out on soil taken from the Calgary Airport site. This testing concentrated upon the performance of Fujibeton and flyash as stabilizers. The results of the laboratory control tests are summarized on Figures 13 and 14. The results of the investigative tests are summarized on Figures 15 through 19. Detailed test results are presented in Volume II of this report.

3.2.1 Changes In Plasticity

The variation of soil plasticity with stabilizer dosage rate is shown on Figure 15. This soil is nonplastic 24 hours after mixing if at least about 3% by weight of Fujibeton is utilized as the stabilizing agent. Flyash without cement does not influence the plasticity index of the soil significantly. Dosage rates up to 13% by weight of flyash produce a negligible change in the plasticity. However, a sample tested after stabilization with 5% flyash combined with 3% cement was nonplastic 24 hours after mixing.

3.2.2 Improved CBR

Figure 16 shows that the CBR of samples of this soil which have been mixed with at least 4% Fujibeton and allowed to cure for seven days is between 25 and 65 times that of untreated soil.

Samples stabilized with flyash alone did not exhibit the same degree of strength increase nor was the strength increase proportional to the flyash addition rate. As shown on Figure 17, the increased CBR value was generally variable from negligible to about 2.5 times the untreated CBR value. However, an increase in CBR value up to about 20 times that obtained for an untreated sample was obtained for specimens where 3% cement together with 5% flyash was utilized to stabilize the soil mixtures.

3.2.3 Improved Durability

The performance of compacted soil stabilizer mixtures during freeze-thaw and wet-dry durability tests are presented on Figure 18. More than 12% Fujibeton is required to meet the PCA guidelines (Ref. 14) for cement stabilized soil durability losses. For the dosage rates selected, the cement and flyash stabilized soils did not meet the PCA guidelines. It should be noted that the maximum flyash content used was 13% and the only cement content investigated was 3%.

Unconfined compressive strengths after durability testing of Fujibeton mixtures are shown on Figure 19. The strengths vary between about 1 MPa and 8 MPa dependant upon the stabilizer dosage rate and type of durability test. Similarly to the other soils tested, the compressive strength was generally lowest for samples subjected to a freeze-thaw durability test.

3.3 PINCHER CREEK

The soil sampled at Pincher Creek is a silty clay with a trace to some sand. Index characteristics are presented in Table 1. The soil will have a high frost susceptibility and high volume change potential.

Two phases of laboratory testing were carried out on samples from the Pincher Creek site. Phase I concentrated upon the performance of Fujibeton and flyash as stabilizers when; whereas, Phase II concentrated upon the performance of flyash in combination with cement as a stabilizing agent.

The results of the laboratory control tests are presented on Figures 20, 21 and 22. The results of the investigative tests are presented on Figures 23 through 26 as well as in Volume II of this report.

3.3.1 Changes In Plasticity

The variation of soil plasticity with stabilizer dosage rate is shown in Figure 23. The soil is nonplastic 24 hours after mixing if at least 5% by weight of Fujibeton or 3% by weight of cement combined with 12% flyash is utilized as the stabilizing agent.

Flyash without cement does not influence the plasticity index of the soil significantly. A general reduction in plasticity index from about 26% to about 20% was noted if at least 2% flyash was incorporated into the soil; however, further reduction could not be achieved even with 16% flyash dosage.

3.3.2 Improved CBR

Figure 24 shows that the CBR of compacted samples of this soil which have been mixed with at least 4% Fujibeton and allowed to cure for seven days is between 4 and 10 times that of untreated soil.

Figure 25 shows that samples stabilized with flyash alone did not exhibit any significant strength increase; however, Figure 26 shows that flyash with cement may produce an increased strength. The measured strength increase was inconsistent. Some samples showed very little gain; whereas, others showed increases up to about 5 times the CBR obtained for an untreated soil sample.

3.3.3 Improved Durability

The performance of compacted soil stabilizer mixtures during freeze-thaw and wet-dry durability tests is very significant. All samples disintegrated during durability testing, except four samples stabilized with 9% or more Fujibeton and subjected to the freeze-thaw durability test. These four samples did not meet the PCA guidelines for cement stabilized soil durability losses. In Volume II specific test data for these samples is presented.

3.4 DRUMHELLER

The soil sampled at the Drumheller site is a silty clay. Index characteristics are presented in Table 1. The soil would have a low frost susceptibility and a very high volume change potential.

One phase of laboratory testing was carried out on soil from the Drumheller site. This testing concentrated upon the performance of Fujibeton and flyash as stabilizers. The results of the control tests are summarized on Figures 27 and 28. The results of the investigative tests are summarized on Figures 29, 30 and 31. Detailed test results are presented in Volume II of this report.

3.4.1 Changes In Plasticity

The variation of soil plasticity with stabilizer dosage rate is shown on Figure 29. These samples of this soil are nonplastic 24 hours after mixing if at least 6% by weight of Fujibeton is utilized as the stabilizing agent.

Significantly flyash seems to have a deterimental influence on the plasticity index of the soil. Figure 29 shows that more than 6% by weight of flyash apparently causes an increase in the plasticity index of the soil. At 16% flyash the plasticity index of the soil mixture was about 60%; whereas, without flyash it was approximately 40%.

3.4.2 Improved CBR

Figure 30 shows that the CBR of samples of the Drumheller soil which have been mixed with at least 6% Fujibeton and allowed to cure for seven days is between 5 and 25 times that of an untreated sample.

Samples stabilized with flyash alone did not exhibit any significant strength gain. However, those formed using 9% flyash with 3% cement did show a small strength gain. The CBR value for the cement and flyash treated soil increased 2 to 10 times that of untreated soil.

3.4.3 Improved Durability

The performance of the compacted soil stabilizer mixture during freeze-thaw and wet-dry durability tests is significant. All samples disintegrated during testing except one specimen stabilized with 16% Fujibeton.

3.5 BASHAW

The soil sampled at the Bashaw site is a uniformly graded fine to medium sand with a trace of silt and a trace of clay. This material is nonplastic and falls within AASHO soil classification A-3 (Ref. 2). Index characteristics are presented in Table 1. This soil would have a high frost susceptibility and negligible volume change potential.

Laboratory testing was carried out on soil from this site primarily to examine the performance of Fujibeton and flyash as stabilizers. The summary results of the laboratory control tests are shown on Figures 32 and 33. The summary results of the investigative tests are presented on Figures 34 through 37. Detailed test results are presented in Volume II of this report.

3.5.1 Improved Workability

The addition of a stabilizing agent can improve the workability of a soil as well as the strength of the compacted soil. Workability is improved if the soil becomes less sensitive to a moisture content increase beyond a critical value. Figure 33 shows that if the moisture content of the Bashaw soil increases above about 10%, the CBR of the compacted soil is greatly reduced. The soil stabilizer mixtures compacted at moisture contents to approximately 12% did not show the same loss in strength. For example Page F39 in Volume II shows that for a mixture containing 4% flyash and tested at 12.9% moisture content the CBR was 28%. In comparison, for the natural soil compacted at that moisture content, the CBR would have decreased significantly from a maximum value of about 34%, to about 12% based upon the data provided on Figure 33.

3.5.2 Improved CBR

As shown on Figure 34, the CBR of compacted and Fujibeton stabilized Bashaw soil was between 4 and 25 times the CBR value of natural soil compacted at the same moisture content. It should be noted, however, that the CBR values of the treated soil mixtures were also greater than 100% when at least 2% by weight of Fujibeton was used as a stabilizing agent. For design purposes unconfined strength properties are more appropriate; however, for comparison purposes, within this project, the CBR data is useful.

The flyash tested did not increase the CBR value of the stabilized soil as significantly as Fujibeton. Generally an increase in CBR value of about 1.5 to 2.5 times the untreated soil compacted at the same moisture content was recorded. This is shown on Figure 35.

Two specimens were formed using 3% flyash and 2% cement combined as the stabilizing agent. One specimen showed a small strength increase to 1.5 times the natural CBR; whereas, the other increased in strength about 25 times.

3.5.3. Improved Durability

The performance of compacted soil stabilizer mixtures for the Bashaw site during feeze-thaw and wet-dry durability tests are presented on Figure 36. About 6% Fujibeton dosage is required to meet the PCA recommended guidelines for cement stabilized soil durability losses. Samples stabilized with flyash alone generally disintegrated in the first two weathering cycles. Soil with 2% cement and 3% flyash (only dosage tested) did not meet the PCA guidelines. The losses noted at this dosage are comparable to those noted at a 4% Fujibeton dosage rate.

Unconfined compressive strengths after durability testing of Fujibeton mixtures are shown on Figure 37. The strengths vary from less than 1 MPa to more than 6 MPa dependant upon the stabilizer dosage rate and the type of durability test. Samples strengths are generally lower after freeze-thaw durability testing than after wet-dry durability testing.

4.0 LITERATURE REVIEW

4.1 GENERAL

A significant quantity of research into the effectiveness of cement or lime for soil stabilization and soil modification has been performed to date. There is also some published work that addresses the use of flyash as a soil improvement agent or as a replacement for bulk soil fill. The information available pertaining to usage of Fujibeton is primarily of the vested interest type and is published through the product supplier.

Where the treated soil mixture is hardened to a low strength concrete-like material, the improvement process is known as soil stabilization. As an alternative to soil stabilization, soils can be improved through modification of the soil plasticity and moisture requirements for field compaction.

Field modified soils are not necessarily cemented although in the short term localized cementation of soils can occur. Benefits of soil modification include reduced swelling potential and improved workability of soils (Refs. 9, 10, 13, 14, 19).

This review summarizes some of the published information for soil improvement agents and indicates potential further research topics that could be appropriate based upon the study reported herein.

4.2 CEMENT AND LIME

The uses of cement and lime in earthworks construction are well known by civil engineers. Cement has been used under controlled and monitored field conditions for about fifty years as a stabilizing agent for subgrades or base courses for road and airfield construction (Ref. 10, 14). Lime mortar has been used since Roman times and for about the past fifty years lime has been used as an engineered soil improvement agent for heavy clays. However, it is only since the 1950's that modified and stabilized soils became widely recognized design alternatives to routine road construction design comprising an asphalt or concrete pavement, a controlled granular base, and a prepared subgrade.

Soil cement base construction is dependant upon several factors including granularity of soil, weathering environment, traffic loading and required construction design life. Experimental and empirical methods have been developed which allow the design of pavement structures (Ref. 3, 10, 12, 13, 15, 16, 17, 18, 20, 21).

In general, the design of pavement structures incorporating soil cement requires that the soil cement base be of a minimum compressive strength or be of sufficient durability so that satisfactory performance is obtained throughout the design life. Standard laboratory testing procedures are available (Ref. 1, 14) for evaluation of soil cement mixtures.

Cement is widely accepted for use as a stabilizer for coarse grained soils such as sands and gravels. These stabilized materials then form the base for further construction or the finished road or airfield surface. Finer grained soils require higher dosage rates of cement in order to obtain a stabilized base (Ref. 3, 10, 14). This can have a significant economic impact upon the road design. Normally treated clayey soils are modified using a relatively small stabilizer dosage rate rather than adopting an expensive stabilization procedure.

Lime is generally significantly less expensive than cement and is a proven modifier of clay soils (Ref. 3, 4, 9, 10, 11, 22). Much research work has concentrated upon the lime requirements for modification of the clay minerals kaolinite, illite and montmorillonite with respect to soil plasticity, field moisture control, strength and permeability. Lime modified soils are not intended to meet the durability of a stabilized base; however, the improved workability can result in significant construction cost savings and modification of the soil can considerably reduce maintenance costs.

4.3 FLYASH

The literature that addresses the use of flyash in earthworks construction is relatively recent. Flyash has been used as a replacement pozzolan in concrete allowing a cost saving through reduced cement requirement. However, it was not until the 1970's that the potential wide range use of flyash combined with cement in earthworks became accepted in North America, although flyash combined with cement had been used in Europe since the 1950's (Ref. 21). The published data presents some laboratory test results; however, extensive laboratory testing programs on various types of soil using flyash alone as a treatment agent do not appear to have been performed. Authors have examined the influence of using the various types of ash available including; dry stored flyash, lagoon ash and bottom ash (Ref. 19, 21).

The distinction between dry stored flyash and lagoon ash is in the method of storage for disposal. Lagoon ash is allowed to settle out in sedimentation lagoons after the ash is washed from the flue particle collector system. Dry ash is stockpiled or retained in hoppers directly after pneumatic removal from the flue gases. Bottom ash is generally in the form of slag gathered from the base of the power station boilers and this material requires crushing prior to use in a controlled construction environment.

The use of flyash in earthworks has been associated with cement or lime improved soils. Flyash has been used alone on a small minority of earthwork projects (Ref. 21). Recently, however, the flyash industry has been promoting further usage of the product as a soil improvement agent. This report examines the usage on one Albertan flyash, Class 'F' ash from Forestburg Power Plant, (a dry stored flyash) as a soil improvement agent.

4.4 CHEMICALS

Over time researchers have examined alternative chemicals suitable for soil improvement such as phosphoric acid, chlorides, natural resins, lignin waste from pulp and paper industry, acrylates, sodium silicate and others (Refs. 6, 10, 22, 25). These chemicals appear to be useful under specific circumstances. It is useful to note that lignin waste has been found to be satisfactory as a dust palliative but not satisfactory as a long term stabilizer of soils (Ref. 6).

A new product on the market, Fujibeton B, contains lignin cellulose, other chemicals and ordinary Portland cement. It is understood that Fujibeton B contains more than 95% Portland cement, although the exact formulation is proprietary data. The suitability of this material for use as a soil improvement agent is detailed in the supplier's promotional literature. There does not appear to be published independant research work which elaborates upon the promotional literature.

On the basis of the manufacturer's data, Fujibeton functions primarily by reducing the surface tension of porewater in soils and dispersing fine soil particles. This allows improved intergranular contact of the cement and soil particles, which enhances the performance of fine grained soils.

4.5 DESIGN OF PAVEMENTS

The literature provides guidance as to the various uses of soil improvement agents and suggests construction methods which provide satisfactory results (Ref. 3, 9, 10, 13, 21, 22, 25). The literature emphasises the need for good quality control during constrution if designs are to be economic. The construction equipment and methods are described in good detail by the Portland Cement Association (Ref. 13) for routine road and airfield pavement base construction.

Design considerations for improvement of soil are numerous, for example: type of earth structure, required design life, static and dynamic loadings, weathering effects and selection of an appropriate improvement agent.

Numerous uses of improvement agents are discussed in the literature such as; roads, airfields, parking areas, storage yards, embankments, reclamation of swamp land or seabed areas, foundation schemes for heavy or vibrating structures, treatment of expansive soils and more. Various design techniques are described for these intended usages (Refs. 3, 7, 9, 10, 12, 15, 16, 17, 18, 20, 21 and 22) and quality control techniques are also discussed.

In the particular field of road and airfield pavement design, some guidance is provided by Shields (Refs. 17 and 18), Mitchell, (Ref. 12), Brabston (Ref. 3), Portland Cement Association (Ref. 15) and Shell Oil Company (Ref. 16).

The Shell method is based upon the number of equivalent standard axle repetitions in the design pavement life and the subgrade modulus. It provides data on the thickness of the surface course, the base course and the subbase course for a given design situation. It is the only method, of those listed above, which can be used to determine an asphalt surface course thickness where stabilized soil is not incorporated into the design. An earlier publication of this method (Shell Design Charts 1963) has been used by others to make a comparison between standard asphalt over gravel pavement construction and pavement construction which incorporates improved soil (Ref. 12). The Shell method has been used in this report as a reference design method, although several other design techniques could have been used. It may be useful to evaluate design methods as an extension to this project.

5.0 ASSESSMENT OF SOIL IMPROVEMENT AGENTS

5.1 FUJIBETON B

Fujibeton B soil stabilizer is marketed by R.J. McMillan Enterprises and manufactured by Fujmasu Synthetic Chemical Laboratory, Tokyo, Japan. The product Fujibeton B contains relatively little lignin cellulose. In fact, it is probably more correct to call it a Portland cement with lignin cellulose as an additive. It contains at least 95% Portland cement and perhaps as much as 98%.

The chemical composition of Fujibeton B is presented in the product literature as:

Ignition Loss	3.0%
Insoluble Residue	0.5%
SiO_2	22.0%
Al_2O_3	5.0%
Fe_2O_3	2.5%
CaO	61.0%
MgO	1.8%
SO_2	2.2%
Others	2.0%

The "others" are stated to comprise:

Lignin$(NaSO_4)_n$
$Na_5P_3O_{10}$
$CaCH_3(CH_2)_{16}COOH$
NaOH
Silica Compounds.

The laboratory testing program comprised numerous basic tests of the type normally carried out when a treated soil is to be incorporated into earthworks construction. Five fine grained soils described in Table 1 were used in the investigation. Dosage rates of the soil treatment agent, Fujibeton, ranged from 1% to 16% by weight of dry soil dependant upon the soil treated and five separate dosage rates as described in Table 5 were investigated for each soil.

Fujibeton treated soil was observed to meet the durability requirements suggested by the Portland Cement Association (Ref. 14) for A-3, A-4 and A-6 soils for the dosage rates examined. The treated samples of A-7-5 and A-7-6 soils tested did not meet the durability requirements at the maximum dosage rate (16% Fujibeton). In fact, virtually all these samples disintegrated during durability testing.

Significant strength gains were noted in treated soils allowed to stand for seven days in humid storage at 20°C and then tested using the California Bearing Ratio method. At small Fujibeton dosage rates (1% to 6%), the CBR value of the treated soil was noted to be more than 25 times the CBR value of the untreated A-4 and A-6 soils tested and more than about 5 times the CBR value of the untreated A-3, A-7-5 and A-7-6 soils tested.

Unconfined compression strength tests were carried out on specimens which remained intact after the durability testing. The freeze-thaw durability test appears to be the more rigourous durability test and generally the strength of specimens following freeze-thaw durability testing were about 1 MPa to 4 MPa lower than the unconfined compressive strength of samples subjected to wet-dry durability tests. These comments apply to the silty A-6 and A-4 soils and sandy A-3 soil tested only, as insufficient data is available for the clayey A-7-5 and A-7-6 samples. Only five clayey samples remained intact after durability testing and the unconfined compressive strength of these samples ranged from 0.22 MPa to 0.92 MPa. The strength of the stabilized A-3, A-4 and A-6 samples ranged up to about 8 MPa and the strength increased with increasing Fujibeton content.

The Atterberg limits of treated soil samples revealed that a small decrease in plasticity was achieved at a low dosage rate (Figure 38); however, treated soil mixtures would become nonplastic when the Fujibeton content was above a relatively low critical dosage rate. The soils were noted to become nonplastic at Fujibeton dosage rates of 2% to 3% for the A-4 and A-6 soils and 5% to 6% for the A-7-5 and A-7-6 soils tested. The A-3 soil examined was nonplastic in the untreated condition.

Based upon the results of this laboratory study Fujibeton B appears to perform satisfactorily as a soil treatment agent. It is suitable for use as a stabilization agent for normal A-3, A-4 and A-6 soils and suitable for use as a modifier for A-7-5 and A-7-6 soils when dosage rates less than 16% by weight of dry soil are utilized. Higher dosage rates may allow the utilization of this product as a stabilizer for highly plastic A-7-5 and A-7-6 soils. However, this possibility has not been examined in this report. It is considered unlikely that the use of a treatment agent at dosage rates exceeding 16% by weight of dry soil would be economic or practical to carry out on large scale construction projects over clayey soils. However, the use of the product could be investigated on a site specific basis if considered appropriate at that time.

5.2 FLYASH

The use of flyash obtained from Battle River Power Plant, Forestburg, Alberta was examined. This material is pneumatically removed from flue gases, stored in hoppers at the Power Plant then shipped by a distributor to the point of use. The flyash examined was Class 'F' ash normally utilized in concrete production.

The chemical composition of the ash from any power plant is variable dependant upon the coal and the boiler efficiency. A standard chemical compostion for Class 'F' ash (from ASTM C618) is given below.

Total ($SiO_2 + Al_2O_3 + Fe_2O_3$)	7.0% Minimum
Sulphur Trioxide	5.0% Maximum
Magnesium Oxide	5.0% Maximum
Loss on Ignition	12.0% Maximum
Available Alkalies as Na_2O	1.5% Maximum

The actual composition of the flyash generally meets these specifications based upon the quality control tests carried out at the power plant. The calcium oxide (lime) content of the flyash is not specified in ASTM C618; however, it was measured to be about 10% in the quality control tests at the power plant. It should be noted that this lime content, represents the cumulative total of free lime and chemically combined lime. The plant quality control data also indicates that the ignition loss is normally about 0.5% or less.

The influence of Battle River flyash on the index properties of the plastic soils tested is shown on Figures 39. It can be seen that the plasticity of the soil flyash mixture generally does not vary in the same manner for each soil with increasing dosage of flyash. The soil from Calgary Bearspaw (A-4 soil) is reduced in plasticity slightly with addition of flyash as is soil from Pincher Creek (A-7-6 soil). However, the soil from Calgary Airport (A-6 soil) did not vary significantly in plasticity even after 12% dosage of flyash and the soil from Drumheller (A-7-5 soil) increased in plasticity when more than 2% flyash was included in the treated soil mixture.

It is concluded that Battle River flyash can have a small beneficial influence upon the index properties of specific soils but that the reaction potential of flyash with any given soil cannot be definitely predicted from the findings of this study.

Compacted samples of treated soil were allowed to cure for seven days and CBR tests were then carried out on the specimens. The results of these tests were compared to CBR tests carried out on untreated soil compacted at the same moisture content. In general the test results indicate that a small strength gain can be achieved for the silty and sandy (A-4, A-6 and A-3) soils particularly when the sample moisture content is above optimum. Clayey soils, however, do not show a consistent strength gain. The strength gains observed were in the range of 50% to 100% of the natural CBR value for sandy and silty soils; however, it should be remembered that at high moisture contents the natural CBR value of these soils may only be about 1%. Some test results indicated strength gains of 200% or more of the natural CBR value but these higher gains do not appear to be consistent and should not be relied upon for earthworks design.

Durability tests were started on flyash treated soil samples; however, none of the samples remained intact throughout the test. Many samples disintegrated during the first or second weathering cycles. It is concluded that flyash treated soil is not suitable for structural earthworks subjected to weathering action.

5.3 FLYASH AND CEMENT

In view of the performance of the Battle River flyash when used as the sole treatment agent, the potential utilization of flyash in combination with normal Portland Cement was examined. Two soils, (Calgary Bearspaw, A-4 and Pincher Creek, A-7-6), were tested using various dosage rates. The other three soils used in this laboratory study were tested using one flyash and cement dosage rate only.

The silty and clayey soils were influenced by the addition of flyash and cement as a combined treatment agent. The soil plasticity was reduced and the strength of compacted soil specimens was increased. At the range of dosage rates selected for this laboratory study compacted specimens did not meet the durability requirements suggested by the Portland Cement Association.

The treated silty soil from Calgary Bearspaw (A-4) was nonplastic using a dosage rate of 2% cement and 5% flyash. The treated clayey soil from Pincher Creek (A-7-6) became nonplastic when the treatment dosage rate was 3% cement combined with at least 12% flyash or at least 4% cement for the range of flyash dosage rates selected.

The strength of the soils examined increased by varying degrees when treated using flyash and cement combined, dependant on the type of soil and the treatment agent dosage rate. The CBR value of the treated silty soil (A-4) was up to about 15 times the CBR of untreated soil. The CBR value of the treated clayey soil (A-7-6) was up to about 4 times the CBR of the untreated soil. The strength observed for the silty soil appears to increase significantly with increasing cement content and to a much lesser extent with increasing flyash content. The strength observed for the treated clayey soil does not appear to increase with increasing cement and flyash content for the range of treatment agent dosages selected for this program.

On the basis of this laboratory evaluation, it is concluded that the utilization of flyash and cement combined as a soil treatement agent could be appropriate for modification of silty and clayey soils and, at high dosage rates for stabilization of some silty soils. The use of the materials for stabilization of sandy soil is also considered feasible.

6.0 COMPARISON OF SOIL IMPROVEMENT AGENTS

6.1 EFFECTIVENESS OF SOIL IMPROVEMENT AGENTS

In making a general comparison of the performance of the various soil treatment agents available on the market, it is important to realize that the chemical composition of a soil may influence the effectiveness of one product but not another and that the intended use of the earthworks and potential weathering actions can also significantly influence the selection of a treatment agent.

In comparison with routinely used cement and lime treatment agents, significant dosage rates of flyash are required to achieve the same modifying effect. In some circumstances it may not be possible to achieve the same modifying effect. Although it may be feasible to obtain a more satisfactory soil modifying effect using Class 'C' flyash, this material is not believed to be produced in Alberta or Saskatchewan, and has not been evaluated during this program. Class 'C' flyash has a higher lime content than Class 'F' ash.

The use of Battle River flyash (Class 'F') in combination with normal Portland cement appears suitable for the stabilization of sandy or silty soils and the modification of clayey soils. It is considered that the pozzonlanic activity of the flyash can be efficiently utilized where silty and sandy soils are to be stabilized, but not for stabilization of clayey soils.

The stabilized silty material from Calgary Bearspaw site showed (Figure 9) a strength gain proportional to the cement dosage and to a lesser extent a strength gain dependant on the flyash dosage; whereas, stabilized clayey material from Pincher Creek site (Figure 26) did not increase in strength for a wide range of flyash dosage rates.

Modification of soil properties using a combination of cement and flyash is primarily dependant upon the cement dosage rate and to a small extent upon the flyash dosage rate. For example clayey soil from Pincher Creek was modified from the natural state to a nonplastic condition utilizing 3% cement combined with 12% flyash by weight of dry soil; whereas, the plasticity index of the soil was only slightly reduced from the natural value of about 28% to about 17% when a dosage rate of 15% flyash by weight of dry soil was used. Modification of soil utilizing such a high dosage rate (15% to 16%) of the treatment agent is unnecessary. Brandl (Ref. 4) suggests a dosage rate of about 5% lime can significantly reduce the plasticity index of a clayey soil.

The results of this laboratory study for Fujibeton B can be compared with typical results expected for cement treated soils provided by the Portland Cement Association (Ref. 14). The Fujibeton material appears to perform at least as well as could be anticipated for cement. The performance comparison presented in Table 6 suggests that for the silty and sandy soils, the Fujibeton material performed better than would be expected for cement. However, unless comparison tests are made on the same soil materials it is unreasonable to conclude that Fujibeton is definitely a superior soil treatment agent. Furthermore the price differential between the products must be considered.

The clayey soils, examined herein, could be modified to a nonplastic state utilizing 6% or less Fujibeton. This dosage rate is comparable with suggested cement or lime dosage rates of 5% to 8% (Ref. 4 and 14). At these dosage rates, cement or lime modified clays may not be completely nonplastic but the volume change potential of the soils would be significantly reduced. Again it appears that the Fujibeton material is slightly more efficient in terms of dosage requirement for treatment of soils. However, it should be stressed that because no reference tests were carried out on these soils using cement or lime, a general conclusion to this effect should be made with caution.

In summary of the above,

i) the performance of flyash above as a treatment agent is not as efficient as cement or lime, and in some cases should not be used at all as a treatment agent.

ii) the performance of flyash and cement combined as a treatment agent is generally less efficient than cement or lime treatment.

iii) the performance of Fujibeton appears to be slightly superior to that of cement or lime, subject to confirmation by direct comparison tests which have not been made in this program.

This study has indicated that Fujibeton is suitable for use as a modifier of clayey soils and a stabilizer of silty and sandy soils and that Battle River flyash can be suitable for use as a modifier of silty soils.

6.2 COST ASPECTS

6.2.1 Comparison For Road Construction

Cost estimates, excluding maintenance, for secondary road construction have been prepared to compare the effectiveness of the various stabilizer alternatives. Basic construction cost data provided by Alberta Transportation are summarized in Table 7. Commercial supply costs for Fujibeton, cement and flyash in Alberta are summarized in Table 8.

Two traffic situations have been examined. These are: 7.5×10^5 equivalent single axle loads (ESAL's) and 3.0×10^6 EASL's which correspond to approximately 100 and 400 ESAL's per day for twenty years, respectively. Drawings defining construction material requirements (Figures 40 and 41) have been prepared using Shell Design Charts (Ref. 16). Furthermore, three basic subgrade conditions for soils evaluated in this study have been considered. These are:

i) Figures 42 and 43 consider the silty soils of the Calgary Airport and Calgary Bearspaw site,

ii) Figures 44 and 45 consider the sandy soil of the Bashaw site, and

iii) Figures 46 and 47 consider the clayey soils of the Pincher Creek and Drumheller sites.

As discussed previously, the durability of treated subgrade is dependant on the dosage rate and the severity of the weathering process.

For the cost comparisons presented herein, the long term strength increases consistent with subgrade stabilization for roads of long design life as well as temporary strength increases consistent with subgrade modification for roads of short design life have been considered. The decreased maintenance costs for roads constructed over a modified subgrade have not been quantified.

6.2.2 Evaluation

It can be seen on Figures 42 to 47, that for road construction the following conclusions are appropriate.

i) Normal road design methods are appropriate over silty subgrades for gravel and asphalt haulage distances of less than about 60 km. Beyond 60 km, it appears to be more economical to design for a stabilized subgrade which meets long term durability requirements. If the road is to be designed for a short life or potential weathering action at the road site is slight, it could be economical to use a modified road design incorporating Fujibeton treatment of the subgrade.

ii) Normal road design methods are appropriate over sandy subgrades for gravel and asphalt haulage distances of less than about 40 km. Beyond that, designs for a short operation life became more economical using Fujibeton. However, for long design life structures, normal construction methods are the most appropriate.

iii) Normal road design methods are appropriate over clayey subgrades where initial capital cost of road construction is to be minimized. The additional cost of lime or Fujibeton as a soil modifier may be offset by reduced maintainance costs. Maintenance costs have not been quantified in this report.

iv) Fujibeton appears to be more cost effective as a soil treatment agent than combined flyash and cement for sandy and silty soils.

v) Lime appears to be more cost effective than Fujibeton as a modifier of clayey soils.

Similarly other soil structures such as airport pavements or large embankments could be examined and the cost effectiveness of treatment agents could be identified. It is considered, however, that the general conclusions reached through the cost analysis for road construction may be extended to other soil structures, with due consideration for additional pavement structure thickness requirements and fill volumes.

7.0 CONCLUSIONS

7.1 POTENTIAL ECONOMIC BENEFITS

This study indicates that Fujibeton is suitable for use as a stabilizer of silty or sandy soils and as a modifier of clayey soils and that flyash is useful when combined with cement as a modifer of silty soils. Cost analyses indicate that treatment of silty and sandy soils using Fujibeton can be economical for road construction projects. In addition soil treatment agents can be used in;

- airfield construction,
- major embankments,
- leisure facilities (campsites, tennis courts, etc.),
- foundation construction,
- reclamation (marshland, river bed and seabed areas),
- containment of landfill,
- temporary earthworks (traffic diversion, detours, remote access, etc.)

The cost effective use of soil treatment agents is feasible for many types of eathwork projects. For each project, and the local site conditions, an individual design assessment is required. The relative costs of gravel haul versus soil treatment potential, reduction in long term maintenance and improved construction site workability for each must be considered. Furthermore regions having a paucity of granular resources and others with poor soils would justify the use of the treatment agents discussed herein.

Government agencies contractors and those involved in private construction can each benefit by the data presented herein. Optimization of design and construction costs can be achieved through the use of soil stabilizers and modifiers. Clearly, two relatively new soil treatement agents have been shown to have desireable properties for specific applications. That these agents make use of waste products of other processes is a further benefit. Although the lignin cellulose content is low (less than 2%) it does function as a successful additive to the cement in the Fujibeton. Similarly the flyash is an abundant waste in some parts of Canada and it has been shown to work well with cement to improve soil behaviour.

7.2 FURTHER RESEARCH TOPICS

During this program, several ideas were generated regarding potential areas for further reserach. Several of these are listed below.

- The field performance of stabilized soils and modified soils are usually monitored during and shortly after construction. Such monitoring programs are performed on a site specific basis for various time periods. It is suggested that a research program comprising a review of available site specific data and further field investigation of projects constructed several years ago and no longer monitored could be beneficial. One objective of this research could be to optimize construction and design methods for earthworks comprising typical fine grained soils.

- Petroleum Operators and Federal Departments in northern frontier areas and the Beaufort Sea are experiencing problems with quality of borrow materials and environmental impact of drilling or production operations. Investigation of the potential use of new materials and techniques for stabilization of muskeg or partial permafrost and improvements in arctic island design by modification or stabilization of seabed or fill materials could be a potentially valuable area of research.

- Over the next few decades considerable growth is planned in the transportation infrastructure for Western Canada. It could be beneficial to evaluate the potential use of flyash, stabilized by cement, lime, Fujibeton or other suitable product, in construction of these projects. Objectives of this research could include an assessment of the use of stabilized flyash from power plants as a surface course for roads and airfields. Increased capability in storage and disposal of contaminated landfill and industrial pollutants is also planned. Liners to reduce leaching from landfill sites and chemical storage areas are based on earthwork construction. The impact of low toxicity wastes on soil stabilized fills and lagoon embankments might be a fruitful research topic.

- A review of agricultural soil maps, surficial geology maps and transportation authority borrow pit records could be carried out to identify regions of Western Canada where substandard subgrade conditions and paucity of local borrow materials exist. This research work would be a useful aid during the design process for major earthwork projects.

- An evaluation of the long term maintenance benefits obtained by incorporation of soil treatment agents would be beneficial. This evaluation could comprise an assessment of reflective cracking often associated with stabilized soil pavements, the economics of overlay design, and the long term effects of road salt or other chemicals which could influence the performance of the treated soil.

REFERENCES

1. American Society for Testing and Materials "Annual Book of ASTM Standards". (1983)

2. American Association of State Highway Official "Recommended Practice for the Classification of Soils and Soil Aggregate Mixtures for Highway Construction Purposes" M 145 - 73.

3. Brabston W.N. et al. (1974) "Soil Stabilization for Roads and Airfields in the Theater of Operations". Miscellaneous Paper S-74-23, U.S. Army Waterways Experiment Station.

4. Brandl H. (1981) "Alteration of Soil Parameters by Stabilization with Lime". Proceedings Int. Conf. Soil Mech. & Found. Eng.

5. Canadian Geotechnical Society (1978) "Canadian Foundation Engineering Manual".

6. Davidson D.T. and Associates "Soil Stabilization with Chemicals" Bulletin No. 193 Iowa Engineering Experiment Station. (1960)

7. Dupas J.M. and Pecker A. (1979) "Static and Dynamic Properties of Sand Cement" A.S.C.E. GT3.

8. Gray D.H. and Lin Y.K. (1972) "Engineering Properties of Compacted Flyash" A.S.C.E. SM4.

9. Gromko G.J. (1974) "Review of Expansive Soils" A.S.C.E. GT6.

REFERENCES (continued)

10. Kezdi A. (1979) "Stabilized Earth Roads" Elsevier Scientific Publishing Company.

11. Lees G., Abdelkater M.O. and Hamdani S.K. (1982) "Effect of the Clay Fraction on Some Mechanical Properties of Lime Soil Mixtures" Journal of Institution of Highway Engineers.

12. Mitchell J.K. et al (1974) "Behaviour of Stabilized Soils under Repeated Loading. Report 6. A Summary Report with a Suggested Pavement Design Procedure" Contract Report 3-145 U.S. Army Waterways Experiment Station.

13. Portland Cement Association (1979) "Soil-Cement Construction Handbook".

14. Portland Cement Association (1971) "Soil-Cement Laboratory Handbook".

15. Portland Cement Association (1970) "Thickness Design for Soil-Cement Pavements".

16. Shell Oil Company (1978) "Shell Pavement Design Manual".

17. Shields B.P. (1975) "Deflection Criteria for Soil-Cement Base Pavements" Alberta Research Council, HTE/75/01.

18. Shields B.P. (1975) "Provisional Method for The Structural Design of Overlays on Soil-Cement Base Pavements" Alberta Research Council OFR 1975-21.

REFERENCES (continued)

19. Sutherland H.B. and Gaskin P.N. (1970) "Factors Affecting the Frost Susceptibility Characteristics of Pulverized Fuel Ash." Canadian Geotechnical Journal Vol. 7.

20. U.S. Army Corps of Engineers "Engineering and Design, Pavement Design for Frost Conditions" EM-110.

21. U.S. Department of Transportation "Flyash A Highway Construction Material" Implementation Package 76-16.

22. Evans G.L. and Bell D.H. (1981) "Chemical Stabilization of Loess, New Zealand". Proceedings Int. Conf. Soil Mech. & Found. Eng.

23 Kawasaki T. Niina A. et al (1981) "Deep Mixing Method Using Cement Hardening Agent" Proceedings Int. Conf. Soil Mech. & Found. Eng.

24. Terashi M. and Tanaka H. (1981) "Ground Improved by Deep Mixing Method" Proceedings Int. Conf. Soil Mech. & Found. Eng.

25. Woods R.D. and Partos A. (1981) "Control of Soil Improvement by Crosshole Testing" Proceedings Int. Conf. Soil Mech. & Found. Eng.

26 Shields B.P. (1965) "A Review of Soil Cement Quantity Control. 1963 Data" Alberta Research Council OFR 1965-7.

LIST OF TABLES

TABLE 1 AVERAGE CLASSIFICATION CHARACTERISTICS OF THE TEST SOILS

TABLE 2 CONTROL TESTS FOR NATURAL SOILS

TABLE 3 PHASE I INVESTIGATIVE TESTING PROGRAM

TABLE 4 PHASE II INVESTIGATIVE TESTING PROGRAM

TABLE 5 INVESTIGATIVE TESTING: STABILIZER DOSAGE RATES

TABLE 6 FUJIBETON B AND CEMENT DOSAGE RATES FOR DURABILITY PERFORMANCE

TABLE 7 ROAD CONSTRUCTION COST DATA BASED ON DISCUSSION WITH ALBERTA TRANSPORTATION

TABLE 8 SOIL TREATMENT AGENT COSTS

TABLE 1

AVERAGE CLASSIFICATION CHARACTERISTICS OF THE TEST SOILS

SITE	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	PLASTICITY INDEX (%)	GRADATION SAND (%)	SILT (%)	CLAY (%)	AASHO CLASSIFICATION (REF. 2)
Calgary Bearspaw	25	18	7	22	53	25	A-4
Calgary Airport	30	18	12	27	48	25	A-6
Pincher Creek	52	25	27	10	45	45	A-7-6
Drumheller	75 - 90	45 - 50	30 - 40	1	30	69	A-7-5
Bashaw	---	---	NP	91	7	2	A-3

TABLE 2

CONTROL TESTS FOR NATURAL SOILS

TEST DESCRIPTION	NUMBER OF TESTS PER SITE
A. PHASE I	
1. Atterberg Limits Determination	2
2. Particle Size Distribution	1
3. a) Standard Proctor Moisture Dry Density Relationship	2
b) Moisture Dry Density Relationship Compactive effort 75% of Standard Proctor Value	2
4. California Bearing Ratio on each specimen compacted for moisture dry density relationship	20
B. PHASE II (Calgary Bearspaw and Pincher Creek Sites Only)	
1. Atterberg Limits Determination	1
2. Particle Size Distribution	1

TABLE 3

PHASE I INVESTIGATIVE TESTING PROGRAM

TEST DESCRIPTION	TYPICAL NUMBER OF TESTS PER SITE
1. Atterberg Limits Determination	
a) Immediately after soil is mixed	10*
b) 1 hour after soil is mixed	10*
c) 24 hours after soil is mixed	10*
2. a) Standard Proctor Moisture Dry Density Relationship (approximately 1 hour after soil stabilizer mixture is obtained).	10
b) Moisture Dry Density Relationship (using 75% of Standard Proctor compactive effort approximately 1 hour after soil stabilizer mixture is obtained).	10
3. a) Freeze-thaw Durability (sample compacted to 95% Standard Proctor maximum dry density).	10
b) As a) (sample compacted at optimum moisture content using 75% Standard Proctor compactive effort).	10
4. a) California Bearing Ratio (sample compacted at optimum moisture content to maximum dry density obtained using 75% or 100% of Standard Proctor compactive effort and cured for seven days).	20
b) Crushing Strength Determination (after completion of freeze-thaw or wet-dry durability tests).	**

---

* The highly plastic clay sampled at Drumheller could not be tested immediately after mixing as it was impossible to obtain a uniform sample moisture content. A minimum delay period of twenty-four hours was incorporated into tests carried out on this soil.

Additional Atterberg Limit determinations were carried out on soil sampled from Pincher Creek and Bearspaw.

The soil sampled from Bashaw was found to be nonplastic.

** The number of crushing strength determinations varied significantly between sites.

TABLE 4

PHASE II INVESTIGATIVE TESTING PROGRAM

TEST DESCRIPTION	NUMBER OF TESTS PER SITE (PINCHER CREEK AND CALGARY BEARSPAW ONLY)
1. Atterberg Limits Determination	
a) 1 hour after soil is mixed	8
b) 8 hours after soil is mixed	8
2. Standard Proctor Moisture Dry Density Relationship (approximately 1 hour after soil stabilizer mixture is obtained.)	8
3. Freeze-Thaw Durability, (sample compacted to 95% Standard Proctor maximum dry density.	8
4. Wet-dry Durability, (sample compacted to 95% of standard proctor maximum dry density).	8
5. a) California Bearing Ratio, (sample compacted at optimum moisture content to maximum dry density obtained using Standard Proctor compactive effort and cured for seven days).	8
b) Crushing Strength Determination (after completion of freeze-thaw or wet-dry durability tests).	Variable

Additional Atterberg Limit determinations were made on samples from Pincher Creek and Drumheller following 48 hours and 72 hours reaction time after soil was mixed.

TABLE 5

INVESTIGATIVE TESTING: STABILIZER DOSAGE RATES

SITE	STABILIZER DOSAGE RATE (% BY DRY WEIGHT)		
	FUJIBETON	FLYASH	CEMENT
A. Phase I Testing			
CALGARY BEARSPAW I	2		
	4		
	7		
	9		
	12		
		2*	
		6	
		10	
		13	
		16*	
		7	3
CALGARY AIRPORT	1		
	2		
	4		
	6		
	10		
		2	
		6	
		10	
		13	
		5	3
PINCHER CREEK	2		
	4		
	7		
	9		
	12		
	16		

* The complete range of investigative testing was not carried out for each of these dosage rates.

TABLE 5 (continued)

SITE	STABILIZER DOSAGE RATE (% BY DRY WEIGHT)		
	FUJIBETON	FLYASH	CEMENT
PINCHER CREEK (continued)		2	
		6	
		10	
		13	
		16	
		7	3
DRUMHELLER	2		
	5		
	8		
	12		
	16		
		2	
		6	
		12	
		16	
		9	3
BASHAW	1		
	2		
	4		
	6		
	10		
		2	
		4	
		6	
		10	
		3	2

TABLE 5 (continued)

SITE	STABILIZER DOSAGE RATE (% BY DRY WEIGHT)		
	FUJIBETON	FLYASH	CEMENT
B. PHASE II TESTING			
CALGARY BEARSPAW II		5	2
		7	2
		10	2
		5	3
		9	3
		7	4
		7	4
		9	4
PINCHER CREEK II		12	3
		12	4
		12	5
		12	6
		12	7
		14	6
		14	7
		16	6

TABLE 6

FUJIBETON B AND CEMENT DOSAGE RATES FOR DURABILITY PERFORMANCE

SAMPLE SITE	SOIL DESCRIPTION (AASHO CLASSIFICATION)	FUJIBETON CONTENT[1] (% BY WEIGHT) WET-DRY DURABILITY	FUJIBETON CONTENT[1] (% BY WEIGHT) FREEZE-THAW DURABILITY	PORTLAND CEMENT CONTENT[2] (% BY WEIGHT)
Calgary Bearspaw	Silt (A-4)	8	10	10
Calgary Airport	Silt (A-6)	9	N/A	12
Bashaw	Sand (A-3)	6	6	9

Notes: 1. As determined in the lab program presented herein.
2. As per Portland Cement Association (Ref. 14).

TABLE 7

ROAD CONSTRUCTION COST DATA BASED ON DISCUSSION WITH ALBERTA TRANSPORTATION (1984 RATES)

ITEM DESCRIPTION		APPROXIMATE COST
1.	Subgrade Preparation	$ 0.50/m^2
2.	Granular Base and Subbase	
	- loading factor	0.77/tonne
	- place and compact	4.30/tonne
	- royalty	0.30/tonne
		$ 5.37/tonne
	- hauling	$ 0.12/tonne km
3.	Asphalt Hot Mix	
	- loading factor	0.77/tonne
	- supply, place and compact	10.00/tonne
		$10.77/tonne
	- hauling	$ 0.12/tonne km

TABLE 8

SOIL TREATMENT AGENT COSTS

ITEM DESCRIPTION	APPROXIMATE COST
Flyash, Class F (Calgary)	$ 42.00/tonne
Flyash, Class F (Edmonton)	26.50/tonne
Flyash, Class F (For The Cost Analysis)	38.00/tonne
Cement, Type 10 (Calgary)	$125.00/tonne
Cement, Type 10 (Edmonton)	135.00/tonne
Cement, Type 10 (For The Cost Analysis)	130.00/tonne
Fujibeton (Alberta)	$220.00 to 330.00/tonne
Fujibeton (For The Cost Analysis)	$250.00/tonne
Pulverized Quicklime (Exshaw)	$ 76.50/tonne
Pulverized Quicklime (Medicine Hat)	105.00/tonne
Pulverized Quicklime (For the Cost Analysis)	100.00/tonne
Subgrade Preparation	
Fujibeton: Bagged Treatment Agent (labour intensive placement)	$ 2.10/m^2
Flyash, Cement, Lime: Bulk Shipment (pneumatic placement from delivery truck)	$ 1.50/m^2

LIST OF FIGURES

FIGURE 1 LOCATION OF SITES EXAMINED

FIGURE 2 PLASTICITY CHART SHOWING AASHO SOIL GROUPS AND MATERIALS INVESTIGATED

FIGURE 3 GRAIN SIZE DISTRIBUTION SAMPLE - CALGARY: BEARSPAW

FIGURE 4 GRAIN SIZE DISTRIBUTION SAMPLE - CALGARY: BEARSPAW II

FIGURE 5 VARIATION OF CALIFORNIA BEARING RATIO WITH MOISTURE CONTENT
SAMPLE - CALGARY: BEARSPAW

FIGURE 6 VARIATION OF PLASTICITY INDEX WITH STABILIZER DOSAGE 24 HOURS AFTER MIXING
SAMPLES - CALGARY: BEARSPAW AND BEARSPAW II

FIGURE 7 VARIATION OF CALIFORNIA BEARING RATIO WITH FUJIBETON DOSAGE
SAMPLE - CALGARY: BEARSPAW

FIGURE 8 VARIATION OF CALIFORNIA BEARING RAIO WITH FLYASH DOSAGE
SAMPLE - CALGARY: BEARSPAW

FIGURE 9 VARIATION OF CALIFORNIA BEARING RATIO WITH FLYASH AND CEMENT DOSAGE
SAMPLE - CALGARY: BEARSPAW II

LIST OF FIGURES (continued)

FIGURE 10 VARIATION OF SOIL STABILIZER LOSSES WITH FUJIBETON DOSAGE AFTER DURABILITY TESTS
SAMPLE - CALGARY: BEARSPAW

FIGURE 11 VARIATION OF SOIL STABILIZER LOSSES WITH FLYASH AND CEMENT DOSAGE AFTER DURABILITY TESTS
SAMPLE - CALGARY: BEARSPAW II

FIGURE 12 VARIATION OF UNCONFINED COMPRESSIVE STRENGTH WITH FUJIBETON DOSAGE AFTER DURABILITY TESTS
SAMPLE - CALGARY: BEARSPAW

FIGURE 13 GRAIN SIZE DISTRIBUTION
(SAMPLE - CALGARY: AIRPORT)

FIGURE 14 VARIATION OF CALIFORNIA BEARING RATIO WITH MOISTURE CONTENT
(SAMPLE - CALGARY: AIRPORT)

FIGURE 15 VARIATION OF PLASTICITY INDEX WITH STABILIZER DOSAGE 24 HOURS AFTER MIXING
(SAMPLE - CALGARY: AIRPORT)

FIGURE 16 VARIATION OF CALIFORNIA BEARING RATIO WITH FUJIBETON DOSAGE
(SAMPLE - CALGARY: AIRPORT)

FIGURE 17 VARIATION OF CALIFORNIA BEARING RATIO WITH FLYASH DOSAGE
(SAMPLE - CALGARY: AIRPORT)

LIST OF FIGURES (continued)

FIGURE 18 VARIATION OF SOIL STABILIZER LOSSES WITH FUJIBETON DOSAGE AFTER DURABILITY TESTS
(SAMPLE - CALGARY: AIRPORT)

FIGURE 19 VARIATION OF UNCONFINED COMPRESSIVE STRENGTH WITH FUJIBETON DOSAGE AFTER DURABILITY TESTS
(SAMPLE - CALGARY: AIRPORT)

FIGURE 20 GRAIN SIZE DISTRIBUTION
(SAMPLE - PINCHER CREEK)

FIGURE 21 GRAIN SIZE DISTRIBUTION
(SAMPLE - PINCHER CREEK II)

FIGURE 22 VARIATION OF CALIFORNIA BEARING RATIO WITH MOISTURE CONTENT
(SAMPLE - PINCHER CREEK)

FIGURE 23 VARIATION OF PLASTICITY INDEX WITH STABILIZER DOSAGE 24 HOURS AFTER MIXING
(SAMPLES - PINCHER CREEK AND PINCHER CREEK II)

FIGURE 24 VARIATION OF CALIFORNIA BEARING RATIO WITH FUJIBETON DOSAGE
(SAMPLE - PINCHER CREEK)

FIGURE 25 VARIATION OF CALIFORNIA BEARING RATIO WITH FLYASH DOSAGE
(SAMPLE - PINCHER CREEK)

LIST OF FIGURES (continued)

FIGURE 26 VARIATION OF CALIFORNIA BEARING RATIO WITH FLYASH AND CEMENT DOSAGE
(SAMPLE - PINCHER CREEK II)

FIGURE 27 GRAIN SIZE DISTRIBUTION
(SAMPLE - DRUMHELLER)

FIGURE 28 VARIATION OF CALIFORNIA BEARING RATIO WITH MOISTURE CONTENT
(SAMPLE - DRUMHELLER)

FIGURE 29 VARIATION OF PLASTICITY INDEX WITH STABILIZER DOSAGE 24 HOURS AFTER MIXING
(SAMPLE - DRUMHELLER)

FIGURE 30 VARIATION OF CALIFORNIA BEARING RATIO WITH FUJIBETON DOSAGE
(SAMPLE - DRUMHELLER)

FIGURE 31 VARIATION OF CALIFORNIA BEARING RATIO WITH FLYASH DOSAGE
(SAMPLE - DRUMHELLER)

FIGURE 32 GRAIN SIZE DISTRIBUTION
(SAMPLE - BASHAW)

FIGURE 33 VARIATION OF CALIFORNIA BEARING RATIO WITH MOISTURE CONTENT
(SAMPLE - BASHAW)

LIST OF FIGURES (continued)

FIGURE 34 VARIATION OF CALIFORNIA BEARING RATIO WITH FUJIBETON DOSAGE (SAMPLE - BASHAW)

FIGURE 35 VARIATION OF CALIFORNIA BEARING RATIO WITH FLYASH DOSAGE (SAMPLE - BASHAW)

FIGURE 36 VARIATION OF SOIL STABILIZER LOSSES WITH FUJIBETON DOSAGE AFTER DURABILITY TESTS (SAMPLE - BASHAW)

FIGURE 37 VARIATION OF UNCONFINED COMPRESSIVE STRENGTH WITH FUJIBETON DOSAGE AFTER DURABILITY TESTS (SAMPLE - BASHAW)

FIGURE 38 VARIATION OF PLASTICITY WITH FUJIBETON DOSAGE 24 HOURS AFTER MIXING

FIGURE 39 VARIATION OF PLASTICITY WITH FLYASH DOSAGE 24 HOURS AFTER MIXING

FIGURE 40 ROAD CONSTRUCTION MATERIAL REQUIREMENTS vs. SUBGRADE CBR (%) TRAFFIC LOAD: 7.5×10^6 ESAL'S

FIGURE 41 ROAD CONSTRUCTION MATERIAL REQUIREMENTS vs. SUBGRADE CBR (%) TRAFFIC LOAD: 3.0×10^6 ESAL'S

FIGURE 42 COST COMPARISON BETWEEN ROAD CONSTRUCTION ON SILTY SUBGRADE AND ON STABILIZER TREATED SUBGRADE, TRAFFIC LOAD: 7.5×10^5 ESAL'S

LIST OF FIGURES (continued)

FIGURE 43 COST COMPARISON BETWEEN ROAD CONSTRUCTION ON SILTY SUBGRADE AND ON STABILIZER TREATED SUBGRADE, TRAFFIC LOAD: 3.0×10^6 ESAL'S

FIGURE 44 COST COMPARISON BETWEEN ROAD CONSTRUCTION ON SANDY SUBGRADE AND ON STABILIZER TREATED SUBGRADE, TRAFFIC LOAD: 7.5×10^5 ESAL'S

FIGURE 45 COST COMPARISON BETWEEN ROAD CONSTRUCTION ON SANDY SUBGRADE AND ON STABILIZER TREATED SUBGRADE, TRAFFIC LOAD: 3.0×10^6 ESAL'S

FIGURE 46 COST COMPARISON BETWEEN ROAD CONSTRUCTION ON CLAYEY SUBGRADE AND ON STABILIZER TREATED SUBGRADE, TRAFFIC LOAD: 7.5×10^5 ESAL'S

FIGURE 47 COST COMPARISON BETWEEN ROAD CONSTRUCTION ON CLAYEY SUBGRADE AND ON STABILIZER TREATED SUBGRADE, TRAFFIC LOAD: 3.0×10^6 ESAL'S

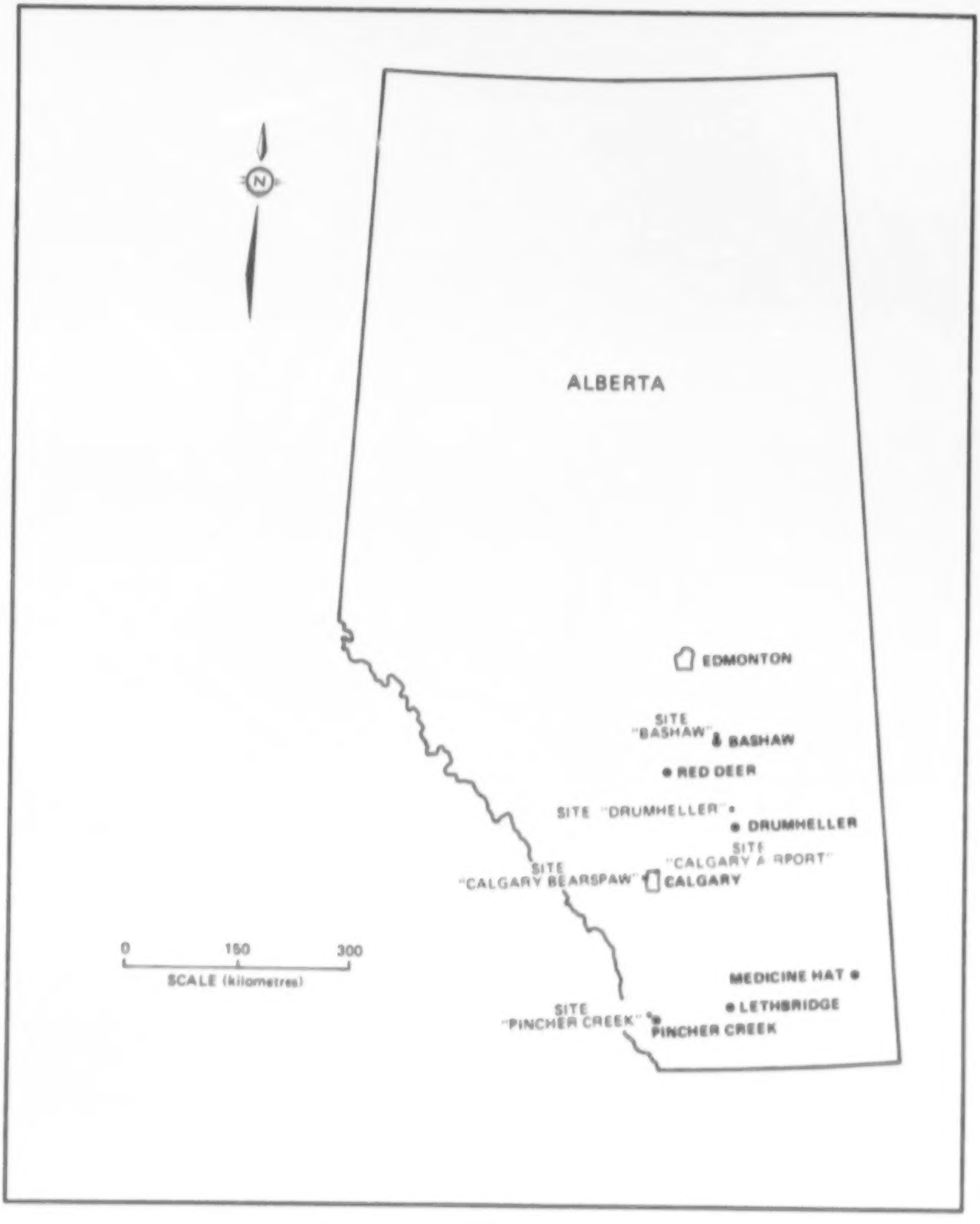

ALBERTA
N
EDMONTON
SITE "BASHAW"
BASHAW
RED DEER
SITE "DRUMHELLER"
DRUMHELLER
SITE "CALGARY AIRPORT"
SITE "CALGARY BEARSPAW"
CALGARY
0
150
300
SCALE (kilometres)
MEDICINE HAT
LETHBRIDGE
SITE "PINCHER CREEK"
PINCHER CREEK

FIGURE 1 LOCATION OF SITES EXAMINED

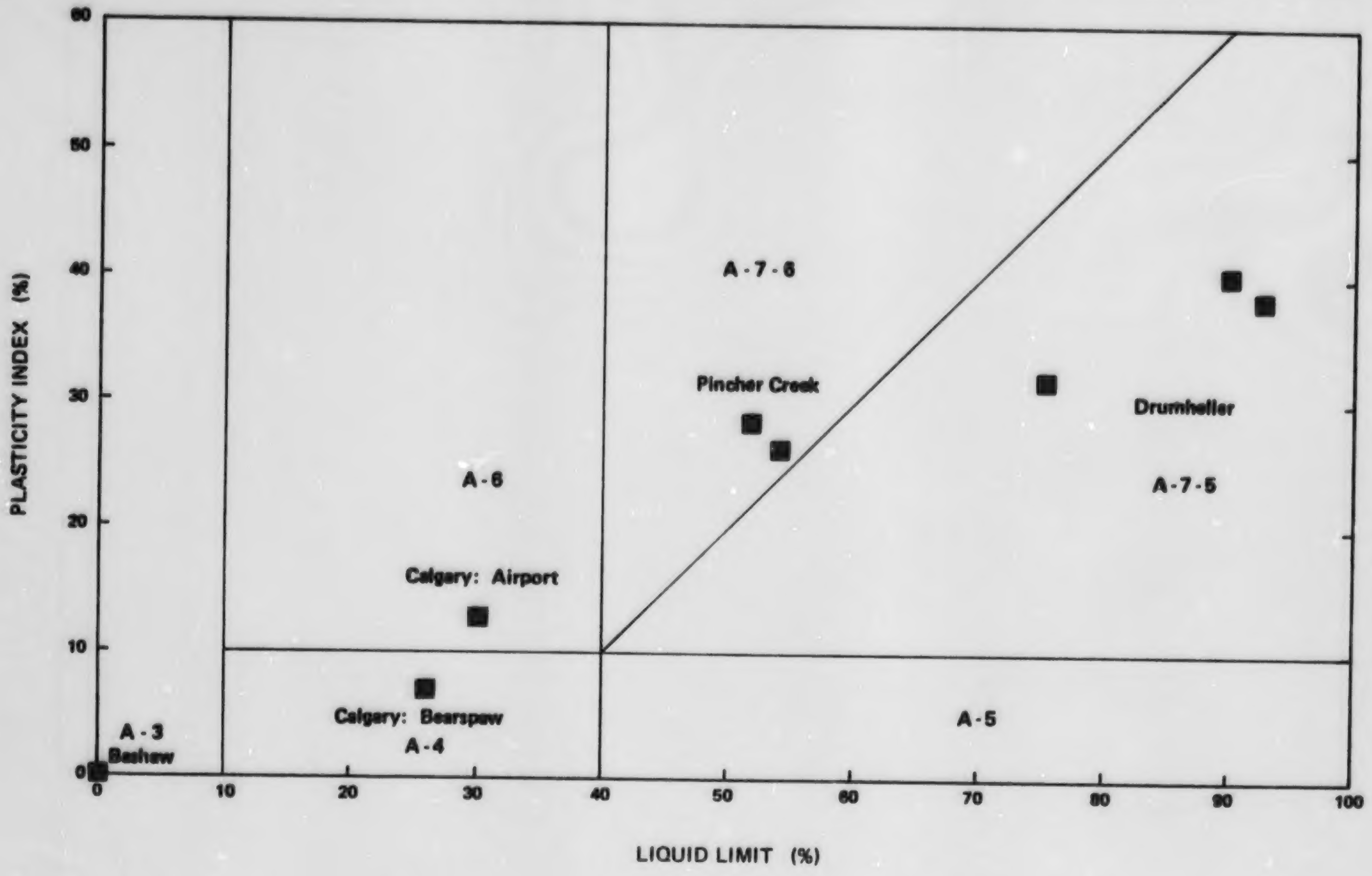


FIGURE 2 PLASTICITY CHART SHOWING AASHO SOIL GROUPS AND MATERIALS INVESTIGATED

GRAIN SIZE DISTRIBUTION

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Calgary: Bearspaw

Sand 24% , Silt 51% , Clay 25%

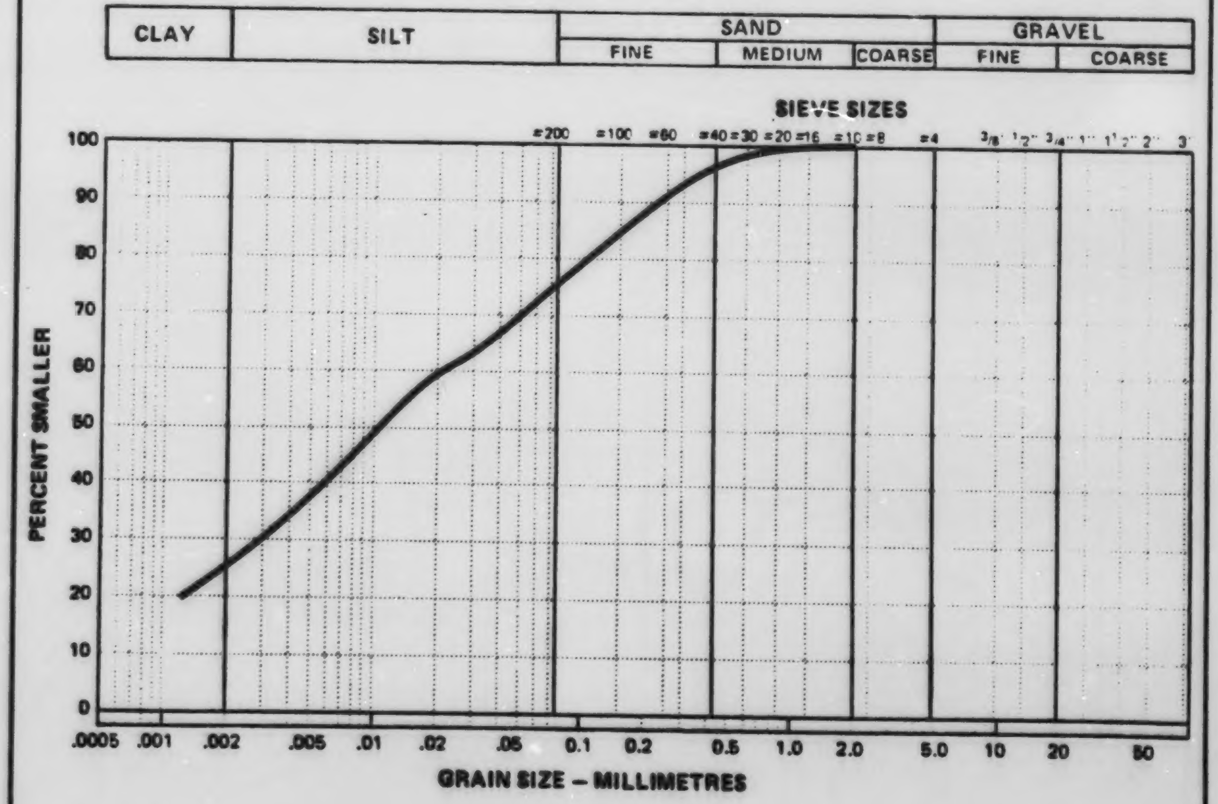


FIGURE 3

GRAIN SIZE DISTRIBUTION

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Calgary: Bearspaw II

Sand 20% , Silt 56% , Clay 24%

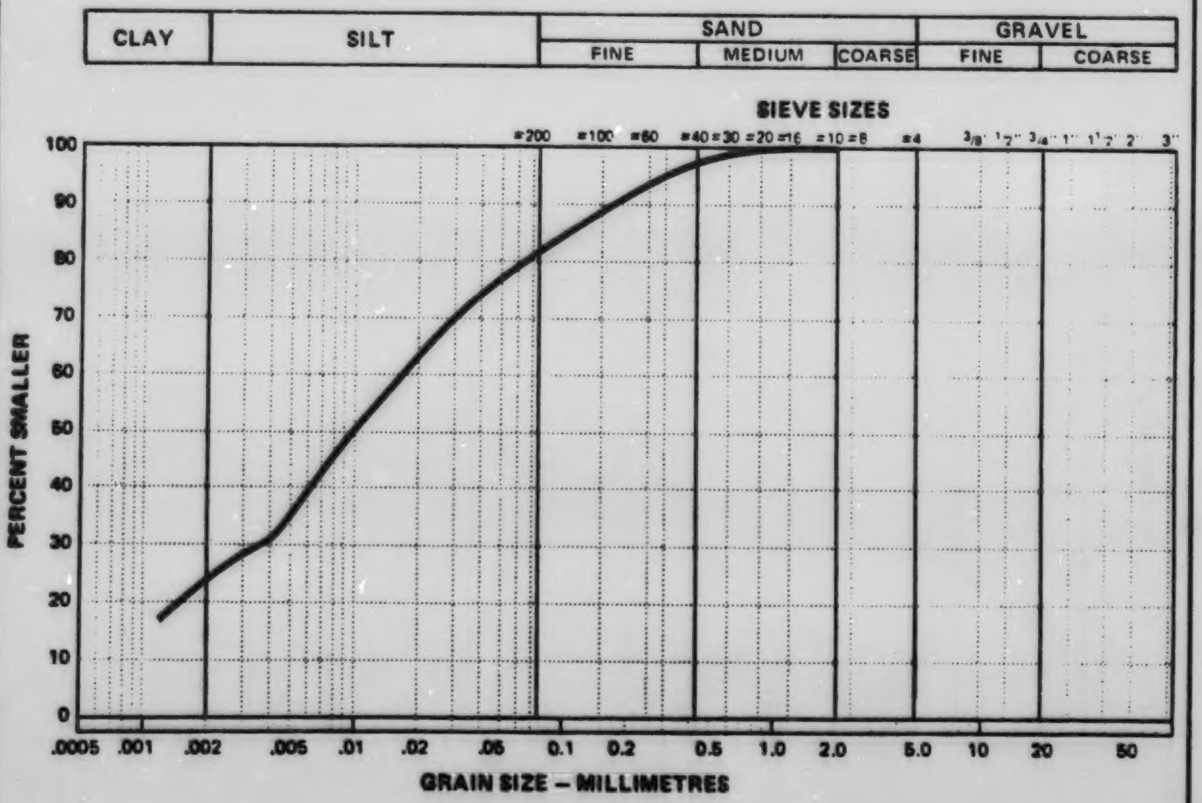


FIGURE 4

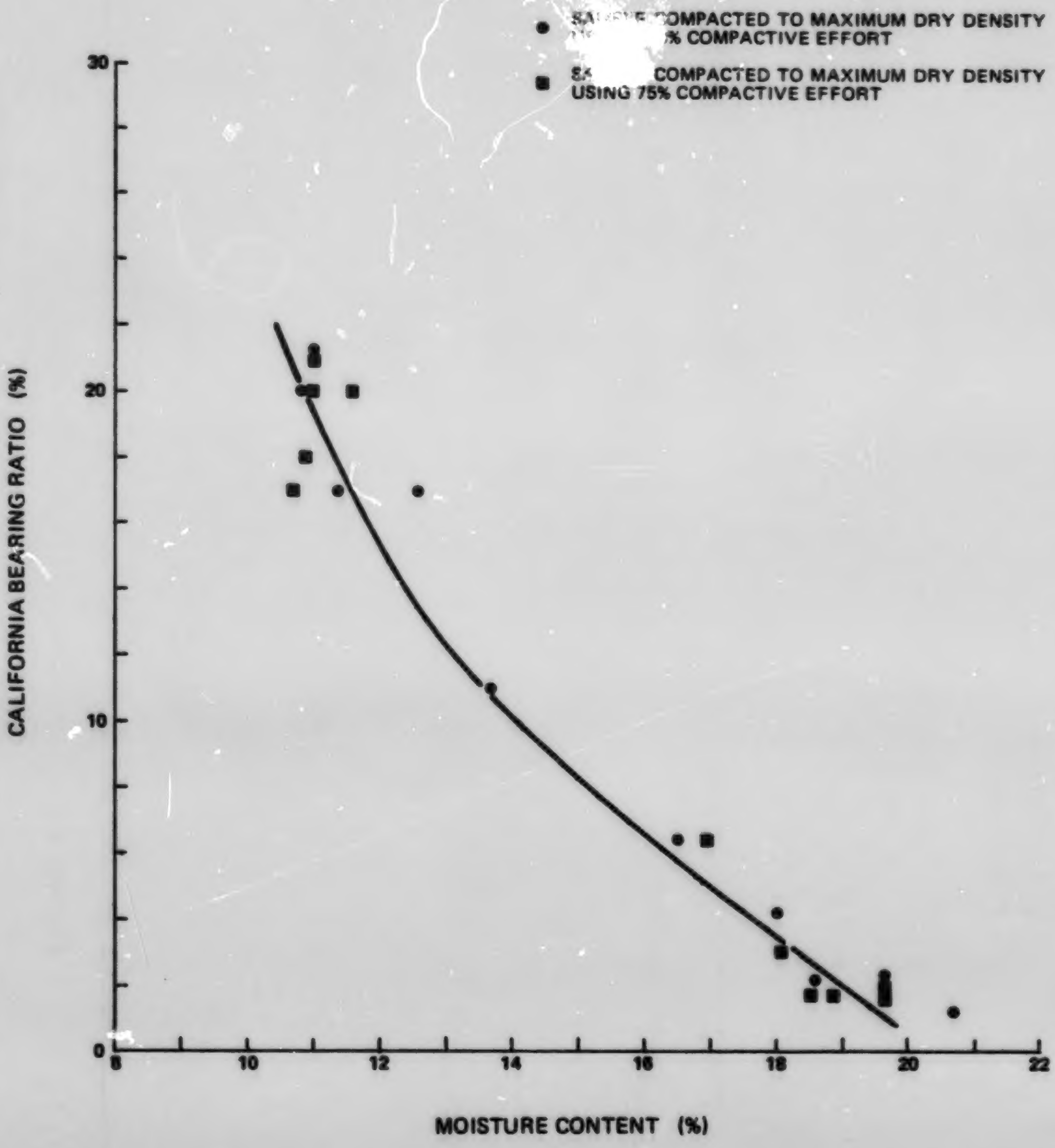
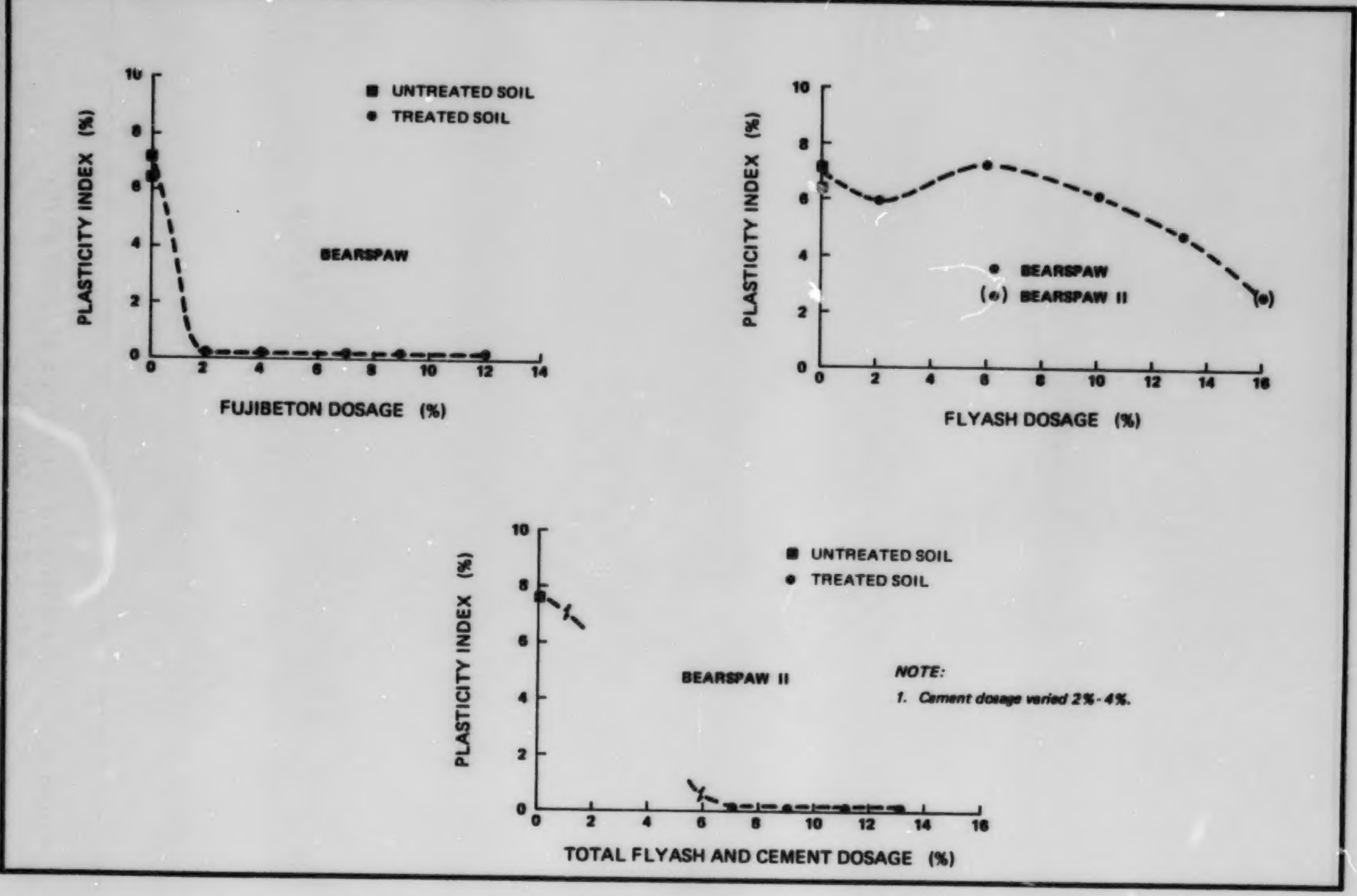


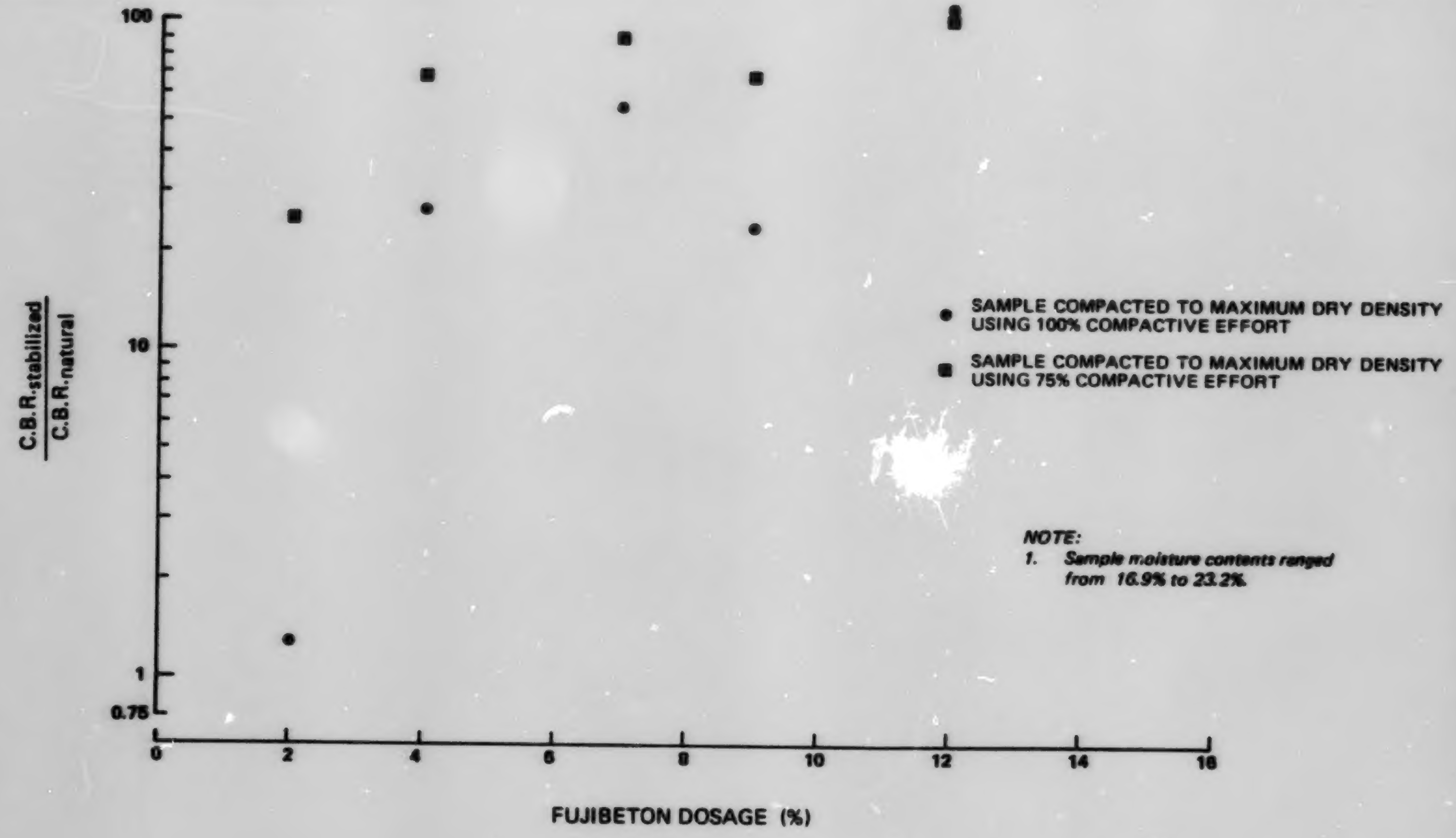
FIGURE 5 VARIATION OF CALIFORNIA BEARING RATIO WITH MOISTURE CONTENT SAMPLE: CALGARY BEARSPAW



NOTE:

1. Cement dosage varied 2% - 4%.

FIGURE 6 VARIATION OF PLASTICITY INDEX WITH STABILIZER DOSAGE 24 HOURS AFTER MIXING SAMPLES – CALGARY: BEARSPAW AND BEARSPAW II



NOTE:
1. *Sample moisture contents ranged from 16.9% to 23.2%.*

FIGURE 7 VARIATION OF CALIFORNIA BEARING RATIO WITH FUJIBETON DOSAGE
SAMPLE – CALGARY: BEARSPAW

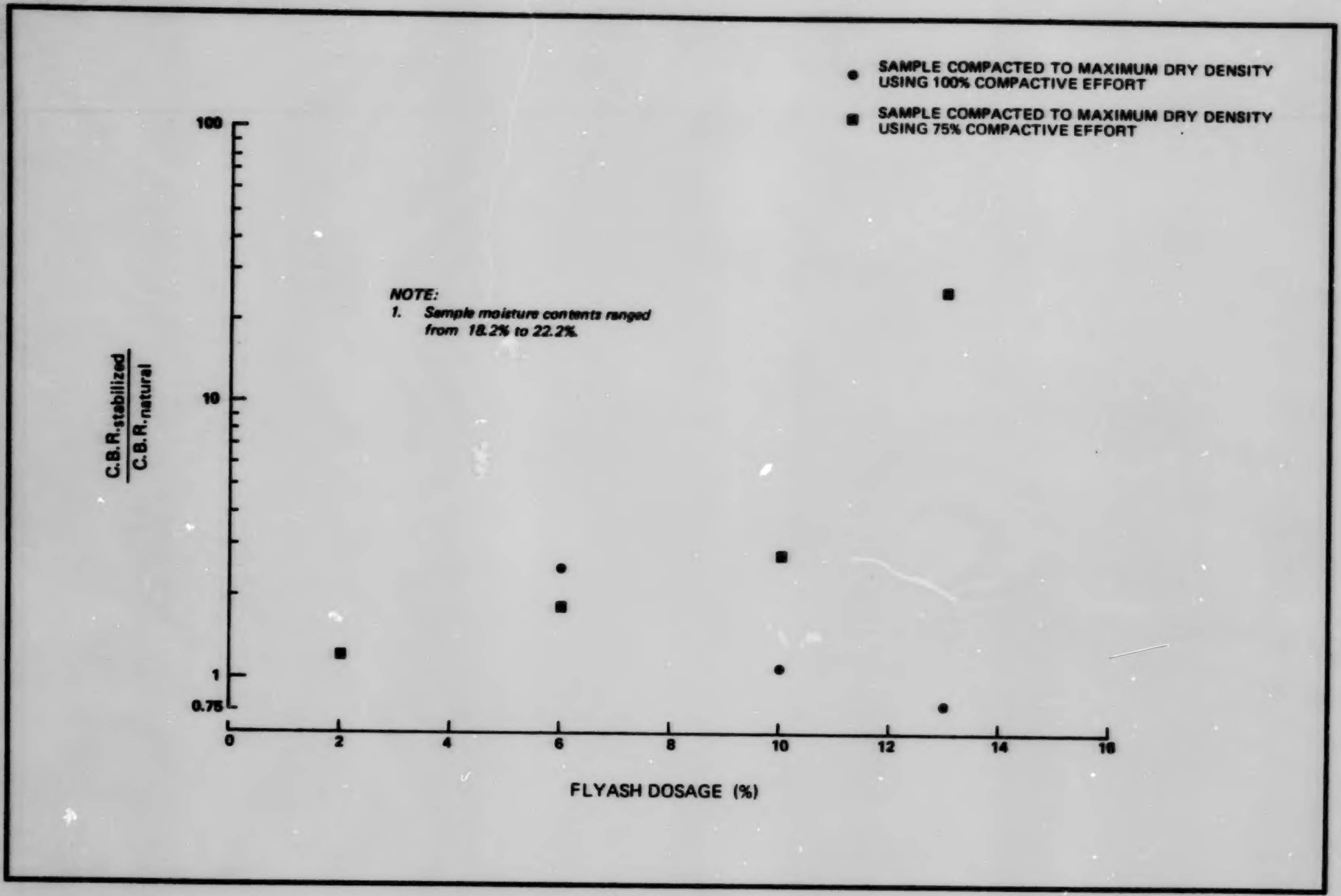


FIGURE 8 VARIATION OF CALIFORNIA BEARING RATIO WITH FLYASH DOSAGE
SAMPLE: CALGARY BEARSPAW

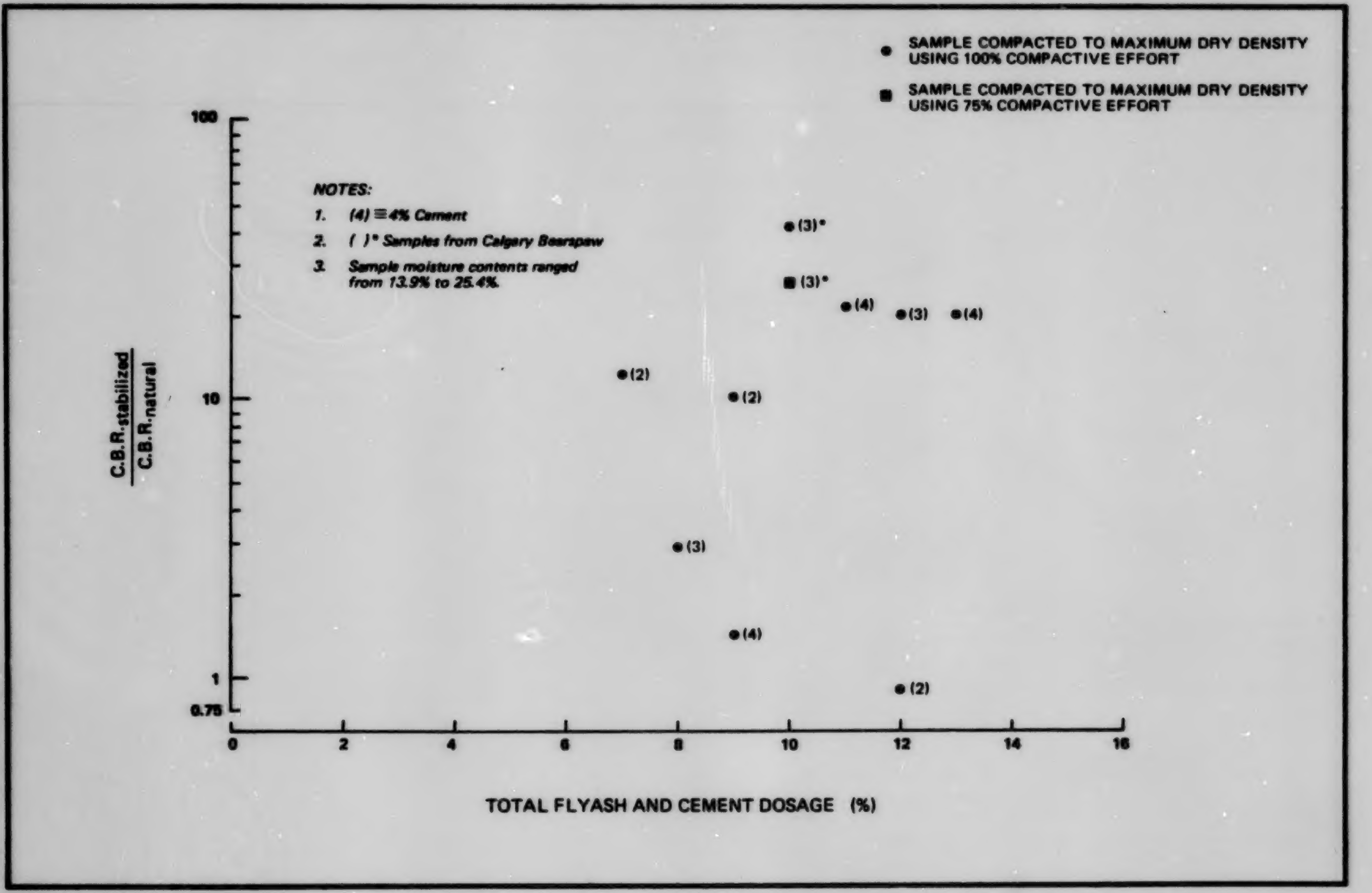


FIGURE 9 VARIATION OF CALIFORNIA BEARING RATIO WITH FLYASH AND CEMENT DOSAGE SAMPLE: CALGARY BEARSPAW II

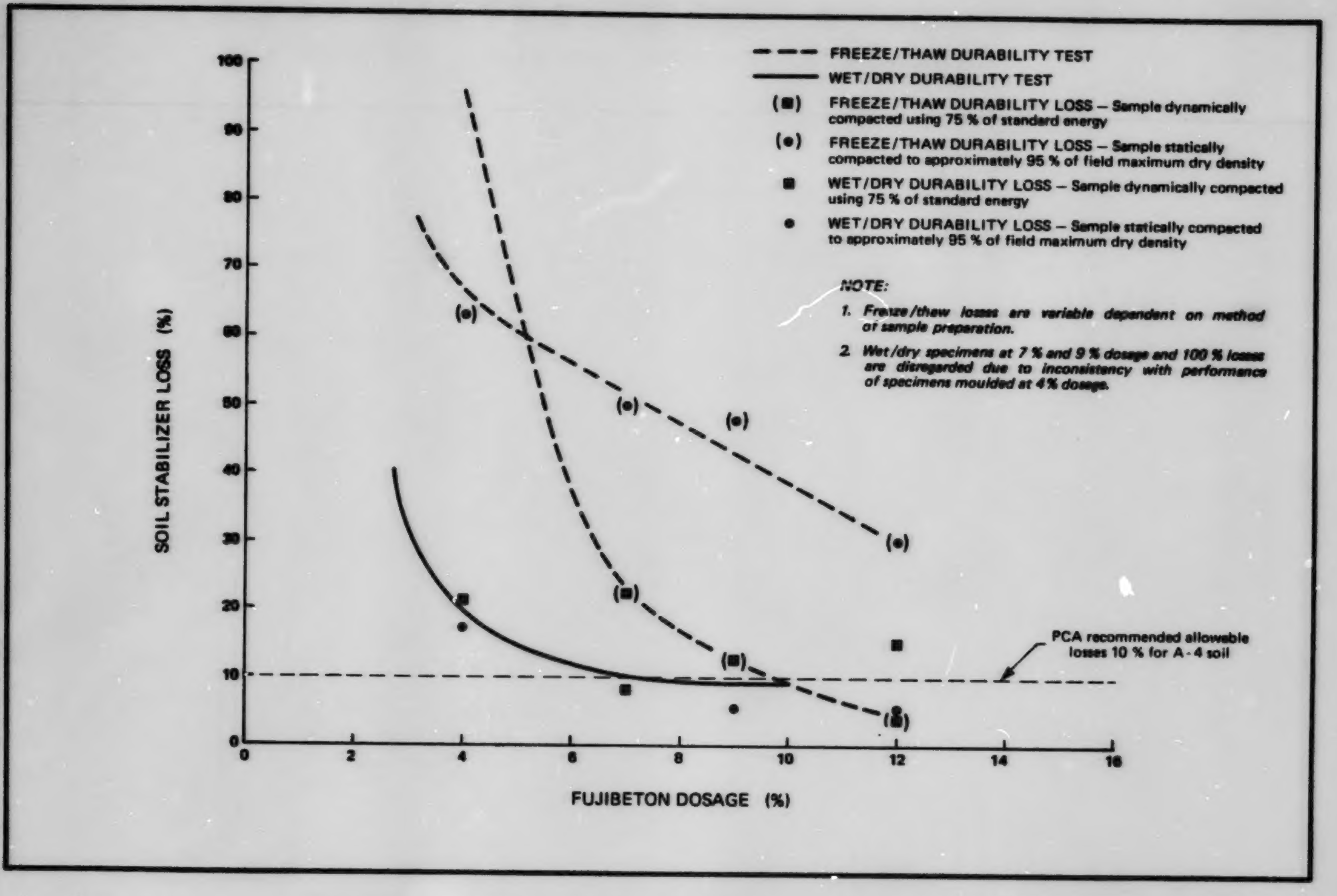


FIGURE 10 VARIATION OF SOIL STABILIZER LOSSES
WITH FUJIBETON DOSAGE AFTER DURABILITY TESTS
SAMPLE –CALGARY: BEARSPAW

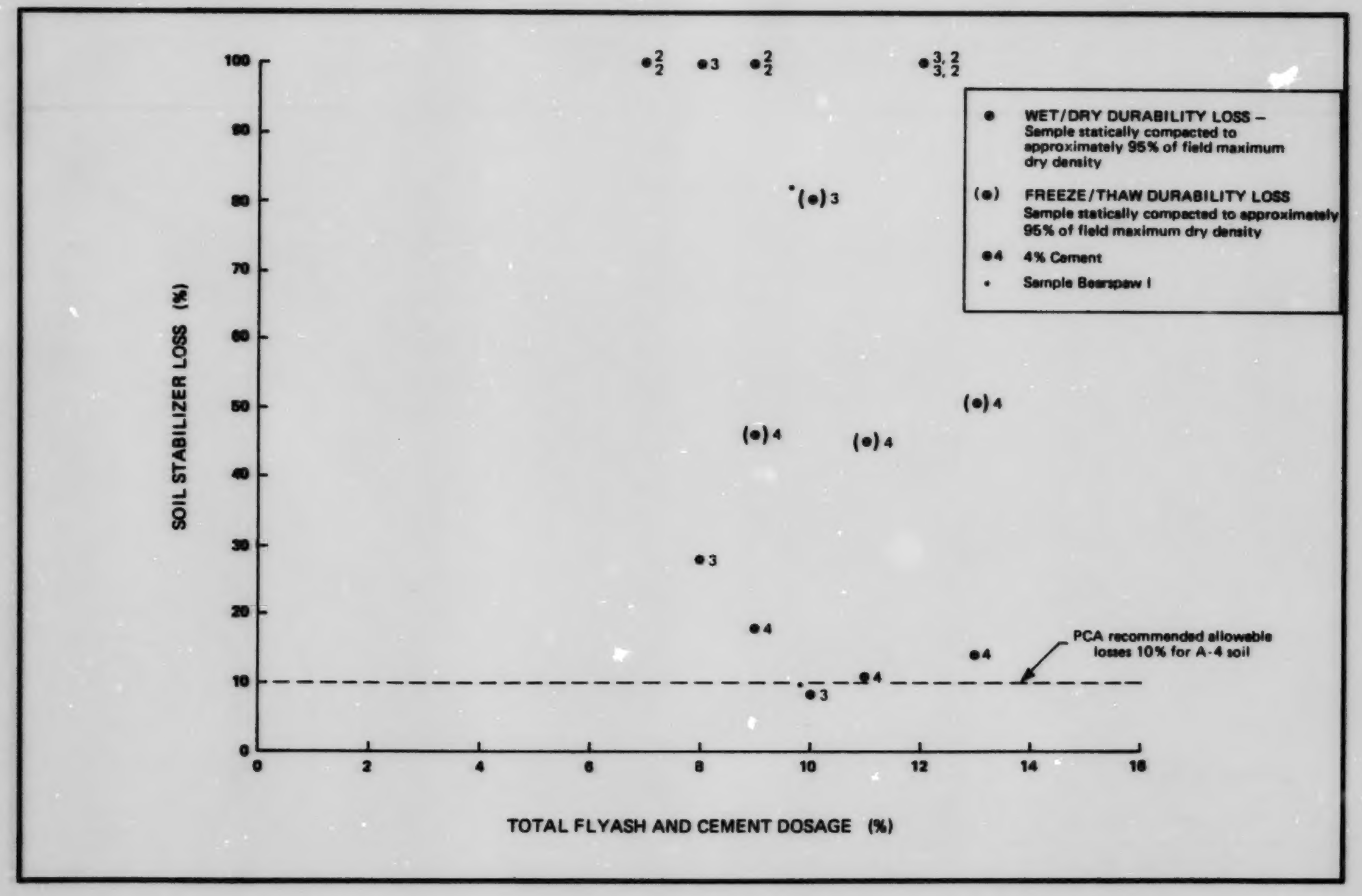


FIGURE 11 VARIATION OF SOIL STABILIZER LOSSES WITH FLYASH AND CEMENT DOSAGE AFTER DURABILITY TESTS SAMPLE – CALGARY: BEARSPAW II

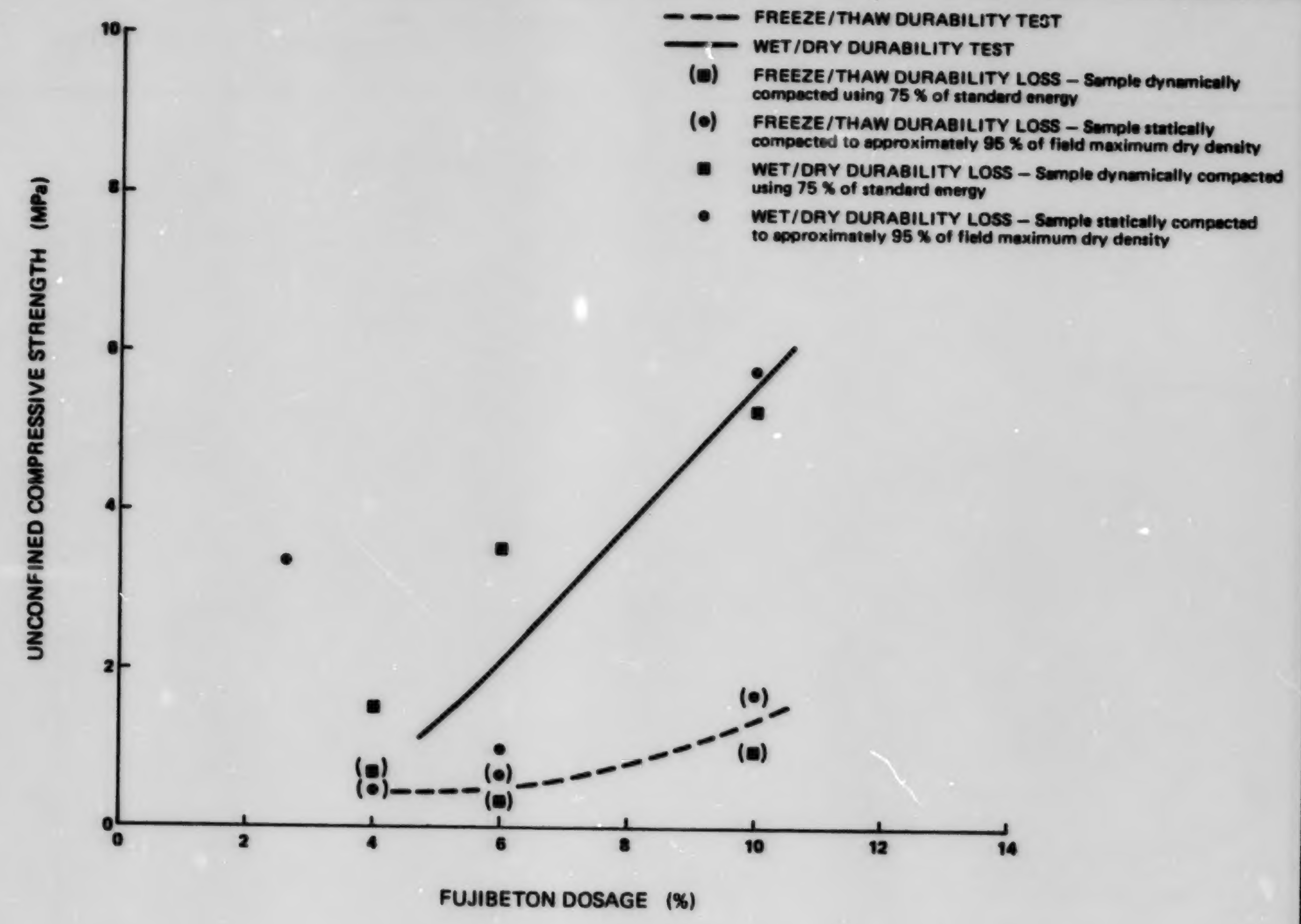


FIGURE 12 VARIATION OF UNCONFINED COMPRESSIVE STRENGTH WITH FUJIBETON DOSAGE AFTER DURABILITY TESTS SAMPLE – CALGARY: BEARSPAW

GRAIN SIZE DISTRIBUTION

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA Contract No.: 1 SD 83-00026

Project No.: 314 - 1264.02

Sample: Calgary: Airport

Sand 27%, Silt 48%, Clay 25%

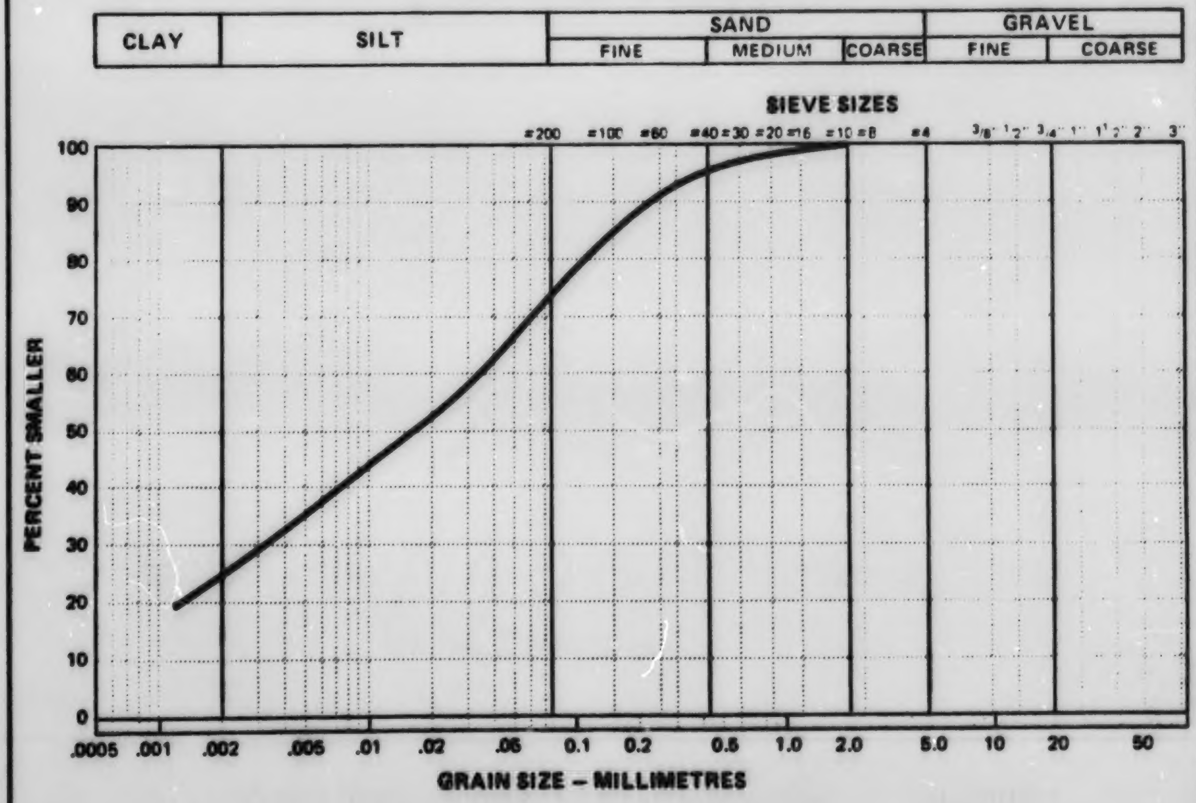


FIGURE 13

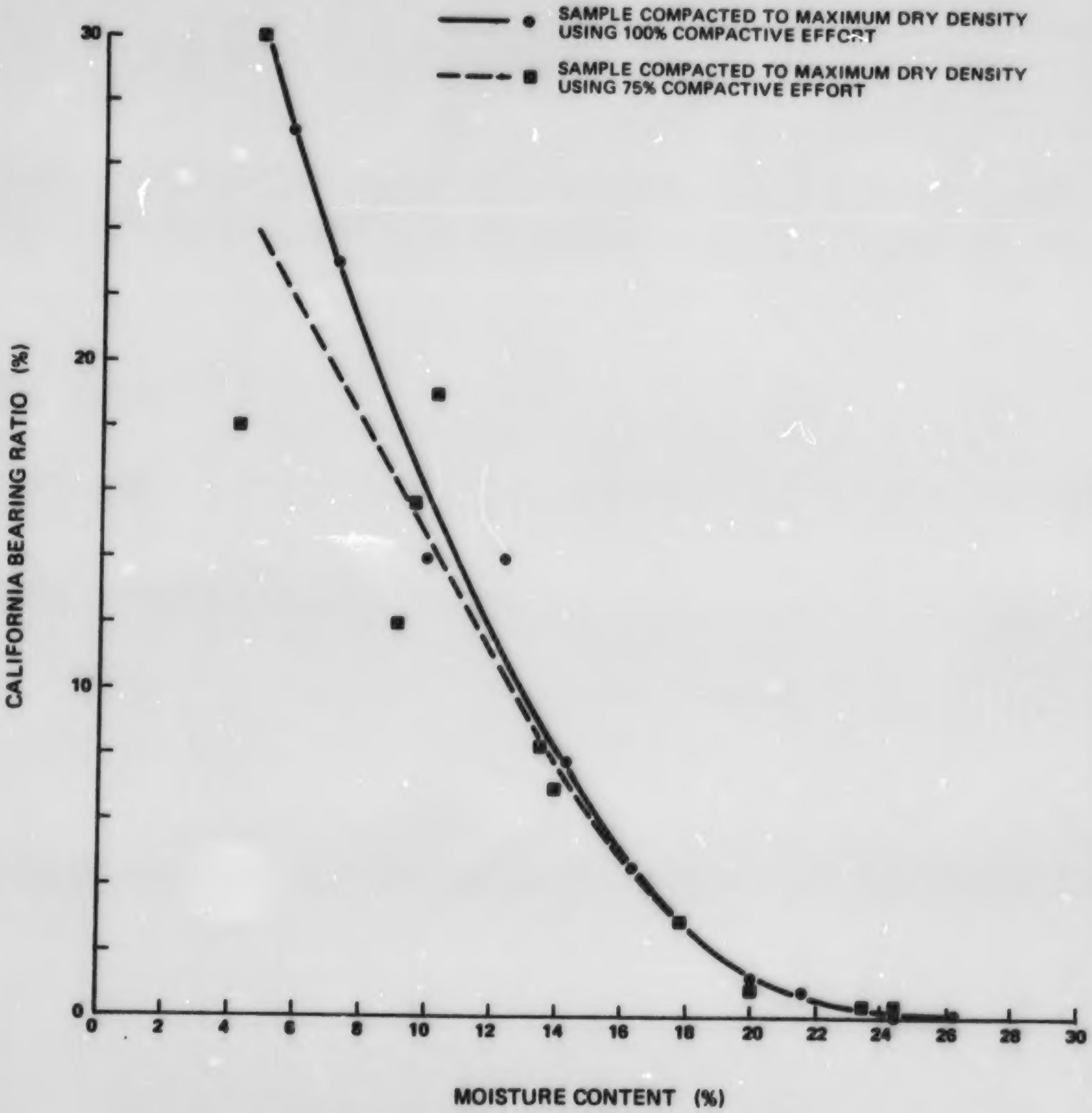


FIGURE 14 VARIATION OF CALIFORNIA BEARING RATIO WITH MOISTURE CONTENT SAMPLE: CALGARY AIRPORT

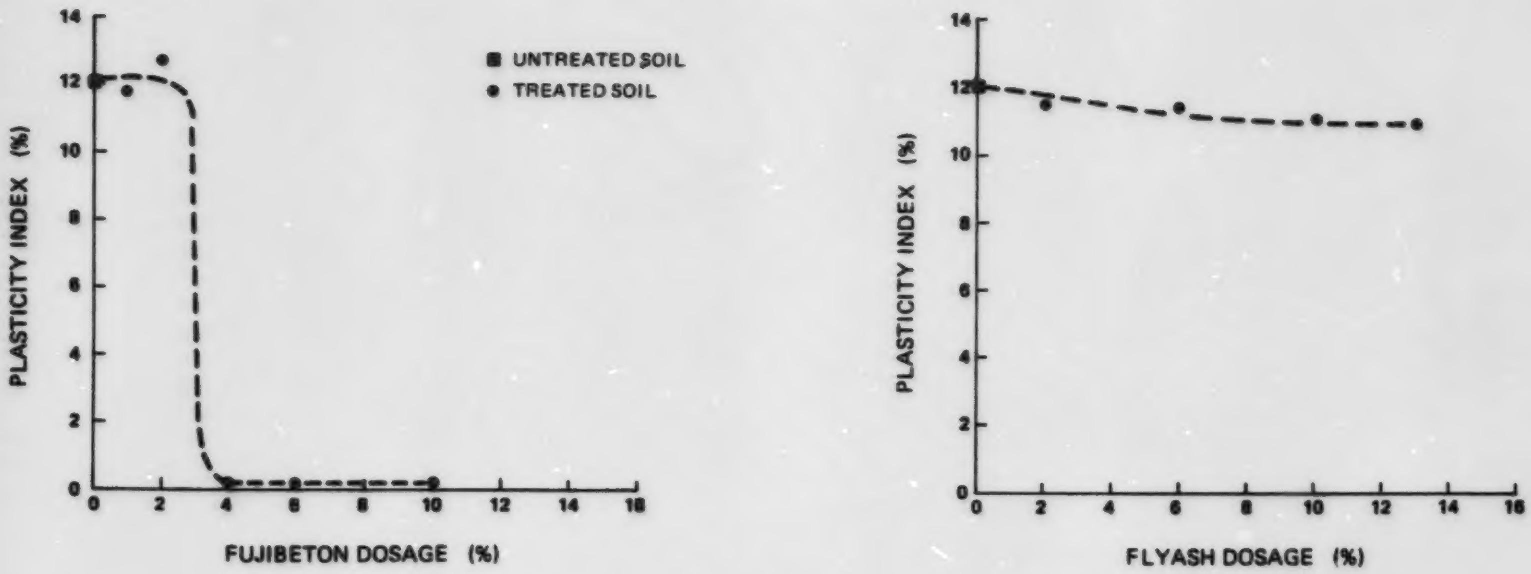


FIGURE 15 VARIATION OF PLASTICITY INDEX WITH STABILIZER DOSAGE 24 HOURS AFTER MIXING SAMPLE – CALGARY: AIRPORT

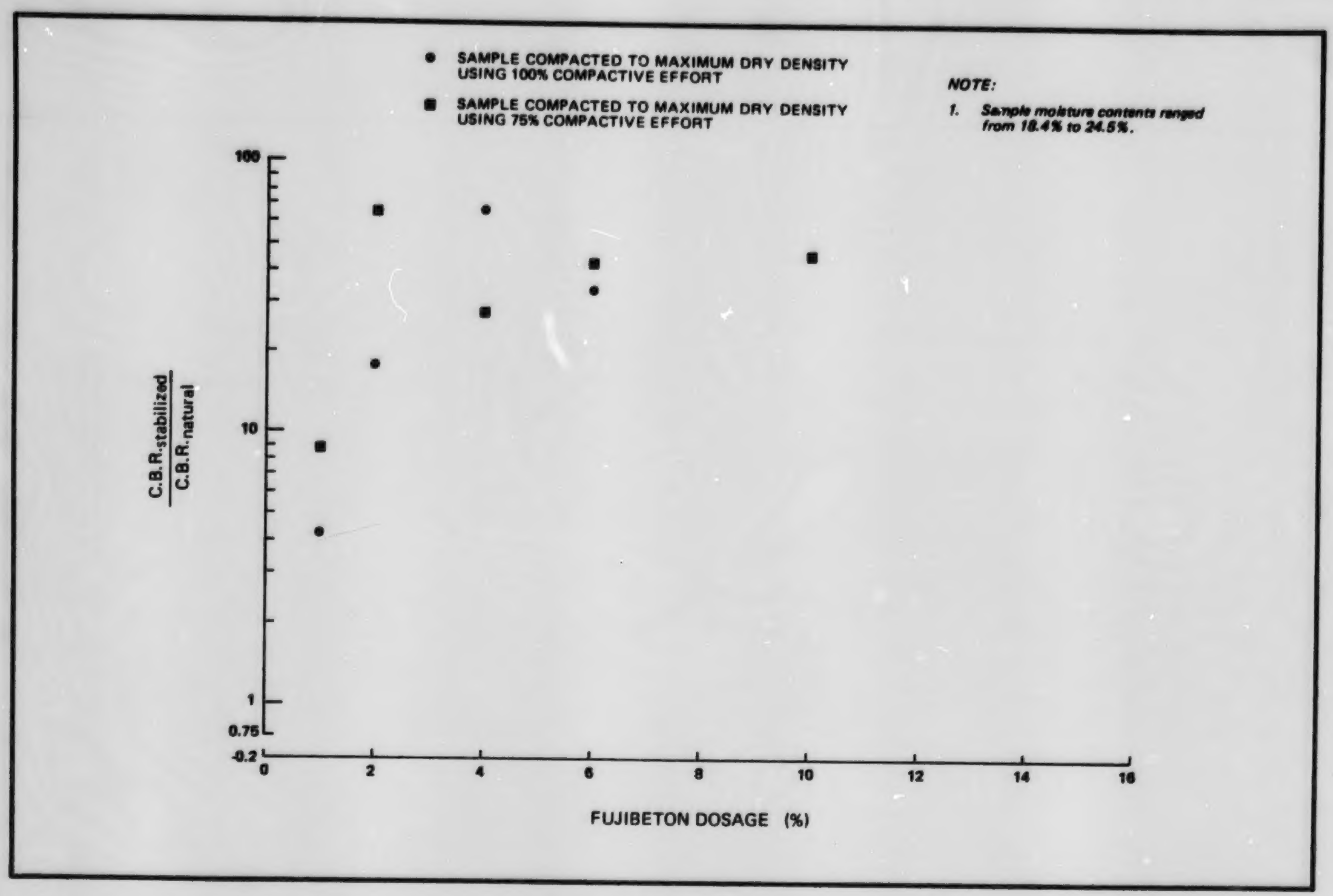
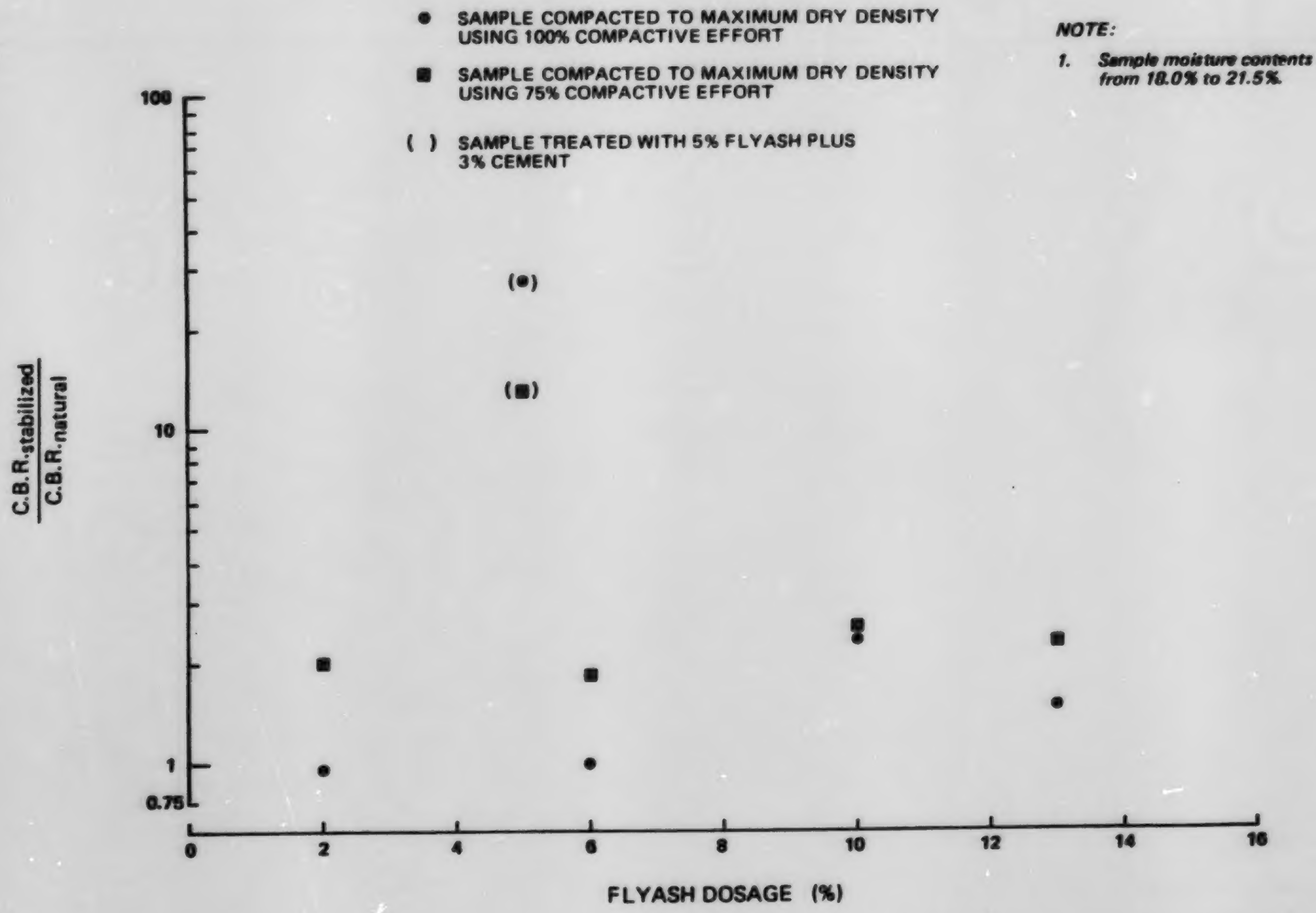


FIGURE 16 VARIATION OF CALIFORNIA BEARING RATIO WITH FUJIBETON DOSAGE SAMPLE – CALGARY: AIRPORT



NOTE:

1. *Sample moisture contents ranged from 18.0% to 21.5%.*

FIGURE 17 VARIATION OF CALIFORNIA BEARING RATIO WITH FLYASH DOSAGE
SAMPLE – CALGARY: AIRPORT

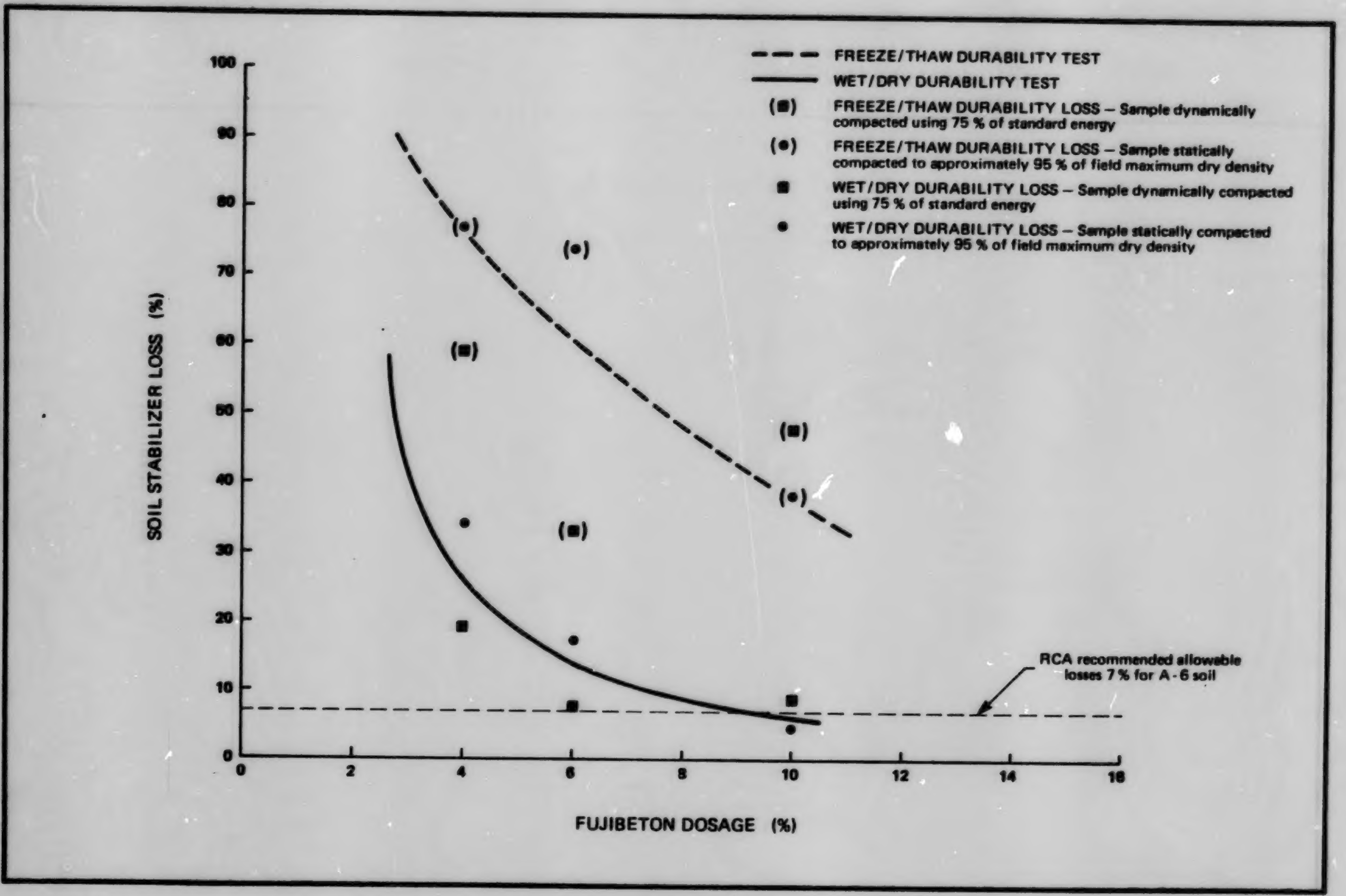
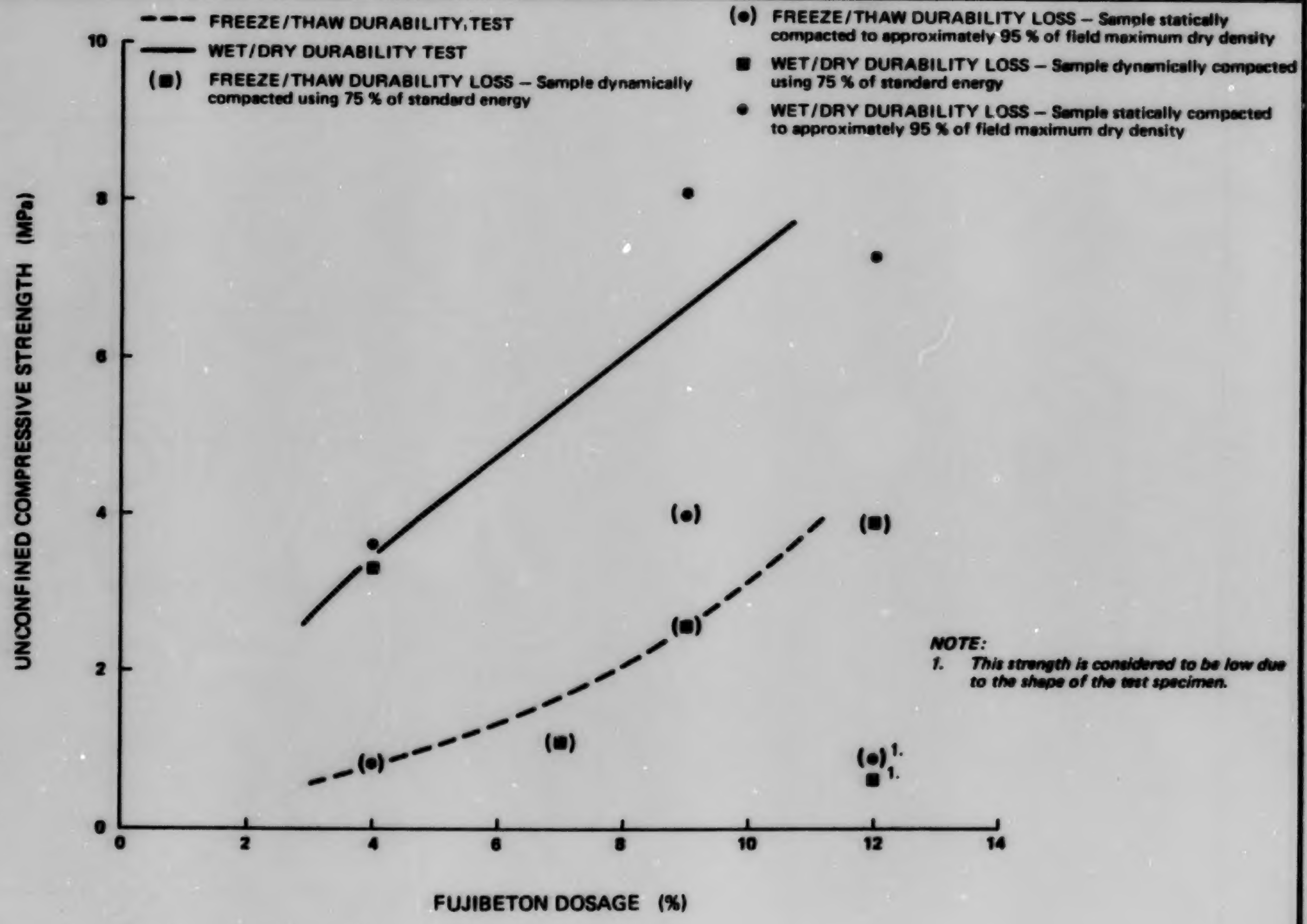


FIGURE 18 VARIATION OF SOIL STABILIZER LOSSES WITH FUJIBETON DOSAGE AFTER DURABILITY TESTS SAMPLE – CALGARY: AIRPORT



NOTE:
1. This strength is considered to be low due to the shape of the test specimen.

FIGURE 19 VARIATION OF UNCONFINED COMPRESSIVE STRENGTH WITH FUJIBETON DOSAGE AFTER DURABILITY TESTS SAMPLE – CALGARY: AIRPORT

GRAIN SIZE DISTRIBUTION

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Pincher Creek

Sand 16% , Silt 46% , Clay 38%

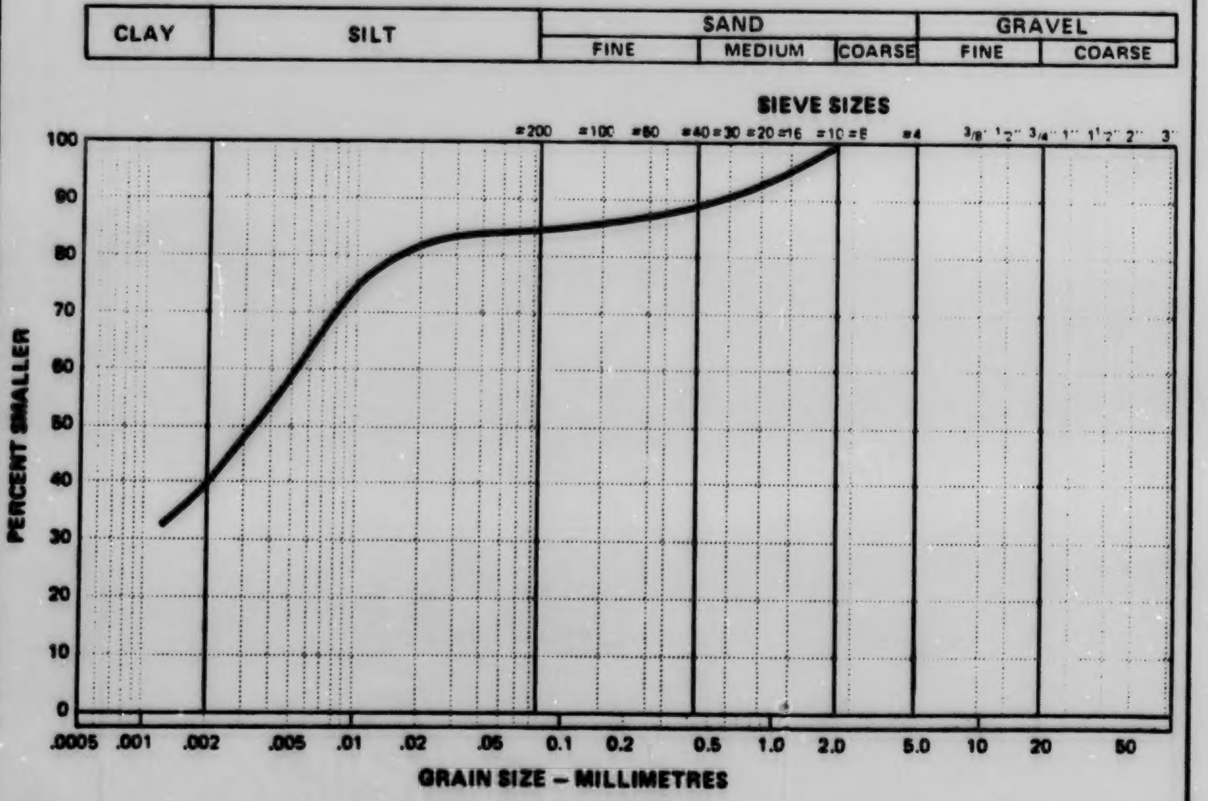


FIGURE 20

GRAIN SIZE DISTRIBUTION

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA Contract No.: 1 SD 83-00026

Project No.: 314 - 1264.02

Sample: Pincher Creek II

Sand 3%, Silt 44%, Clay 53%

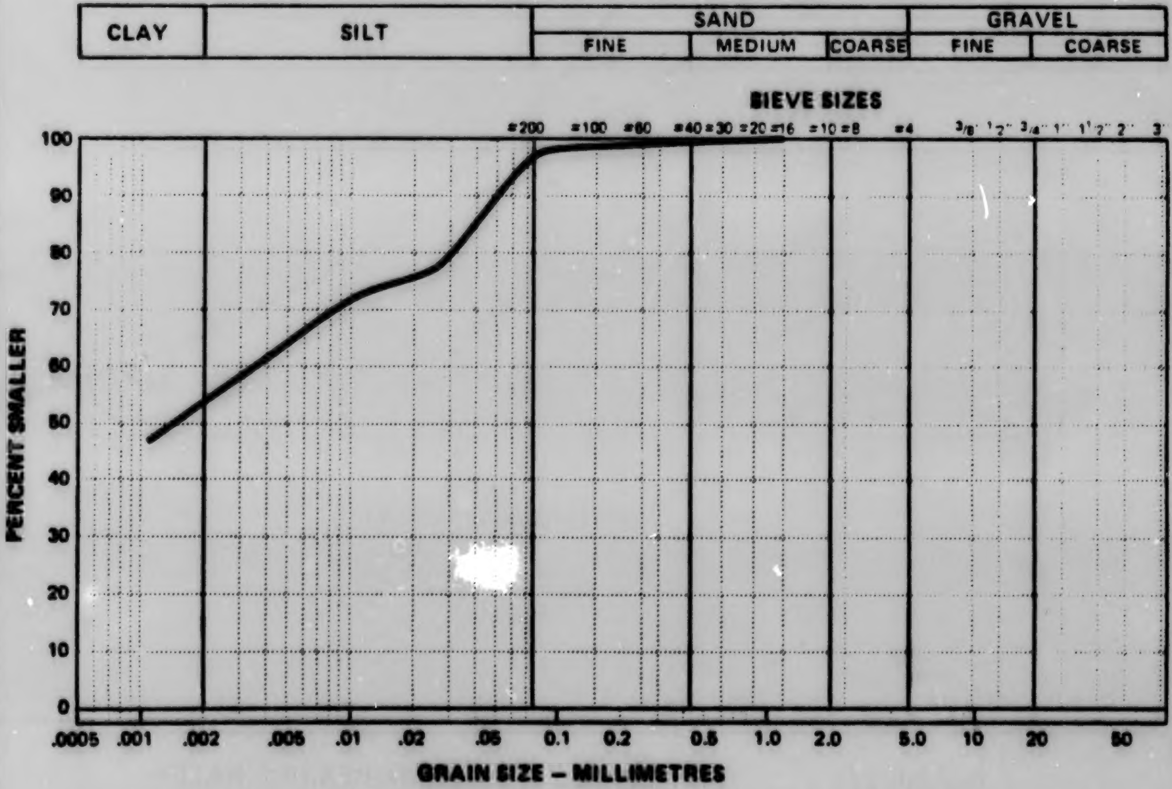


FIGURE 21

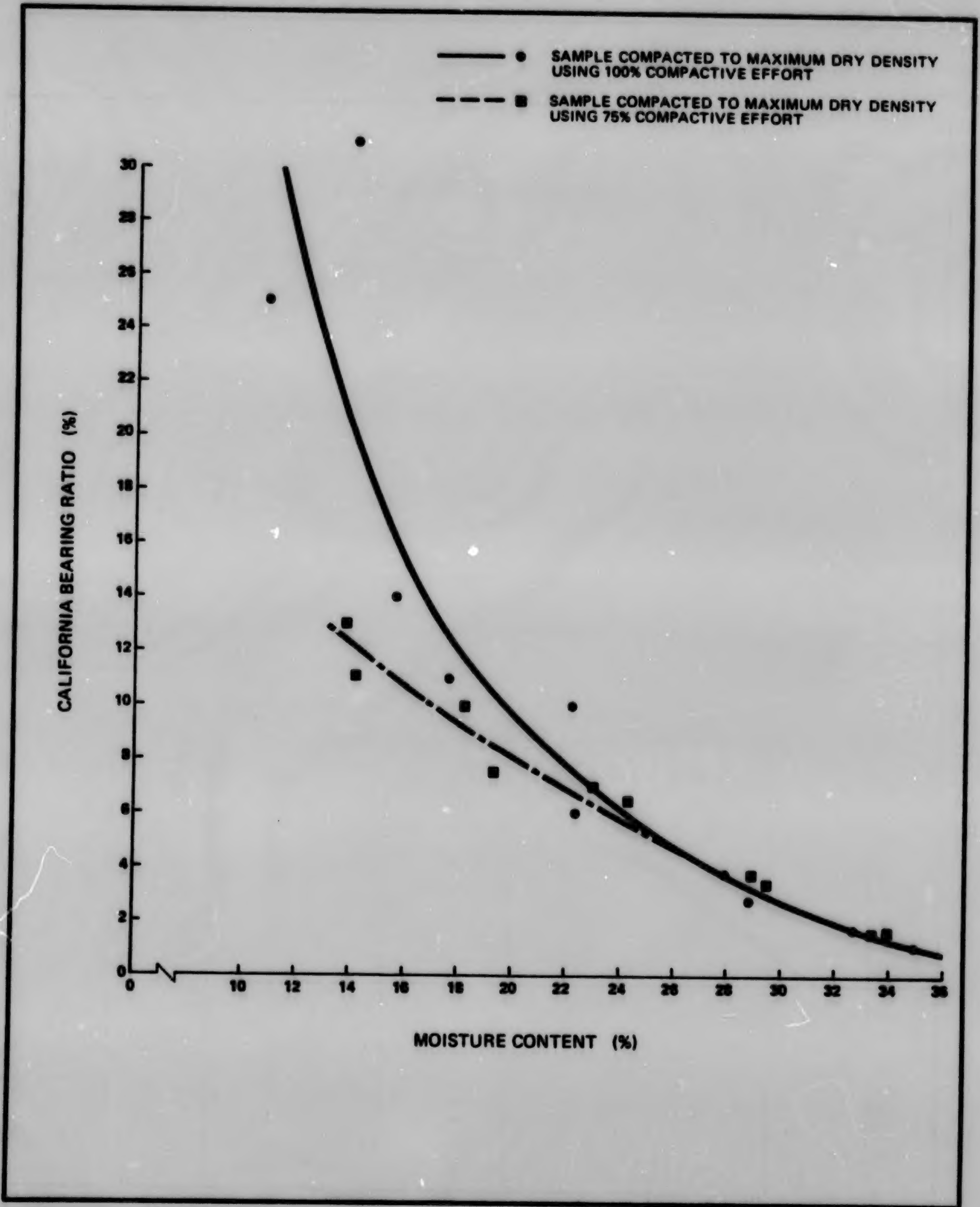


FIGURE 22 VARIATION OF CALIFORNIA BEARING RATIO WITH MOISTURE CONTENT SAMPLE – PINCHER CREEK

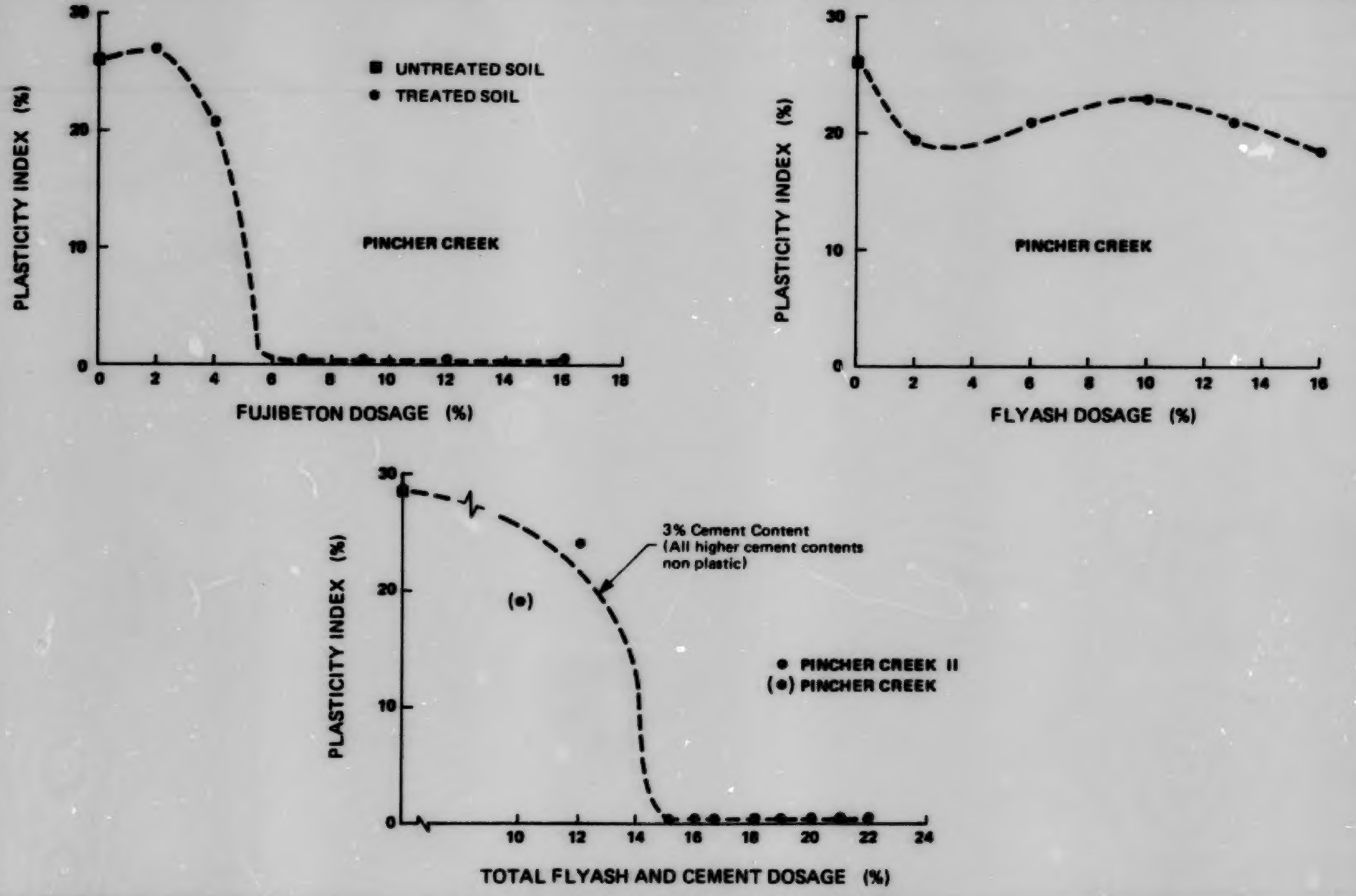


FIGURE 23 VARIATION OF PLASTICITY INDEX WITH STABILIZER DOSAGE 24 HOURS AFTER MIXING SAMPLES – PINCHER CREEK AND PINCHER CREEK II

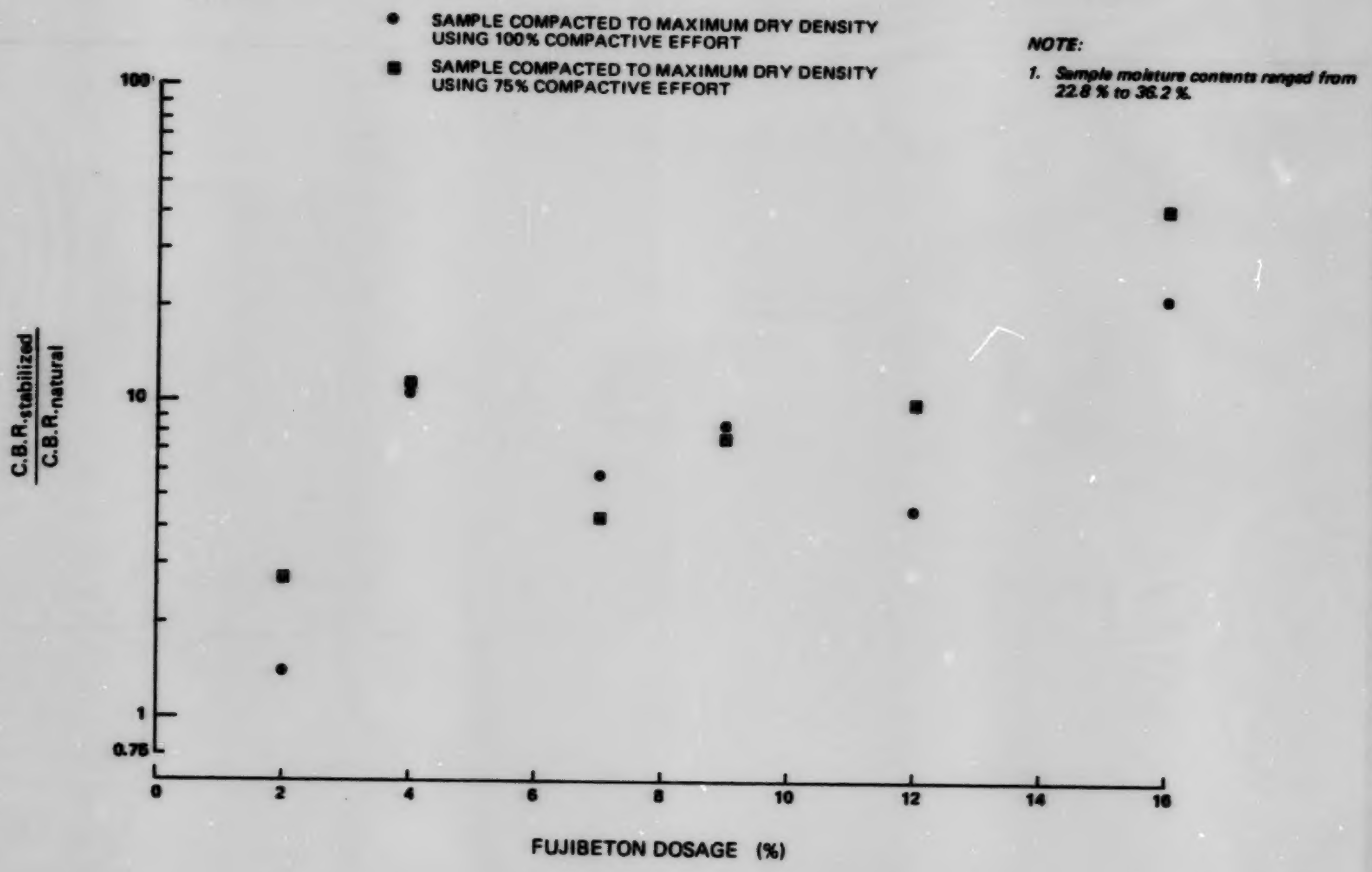
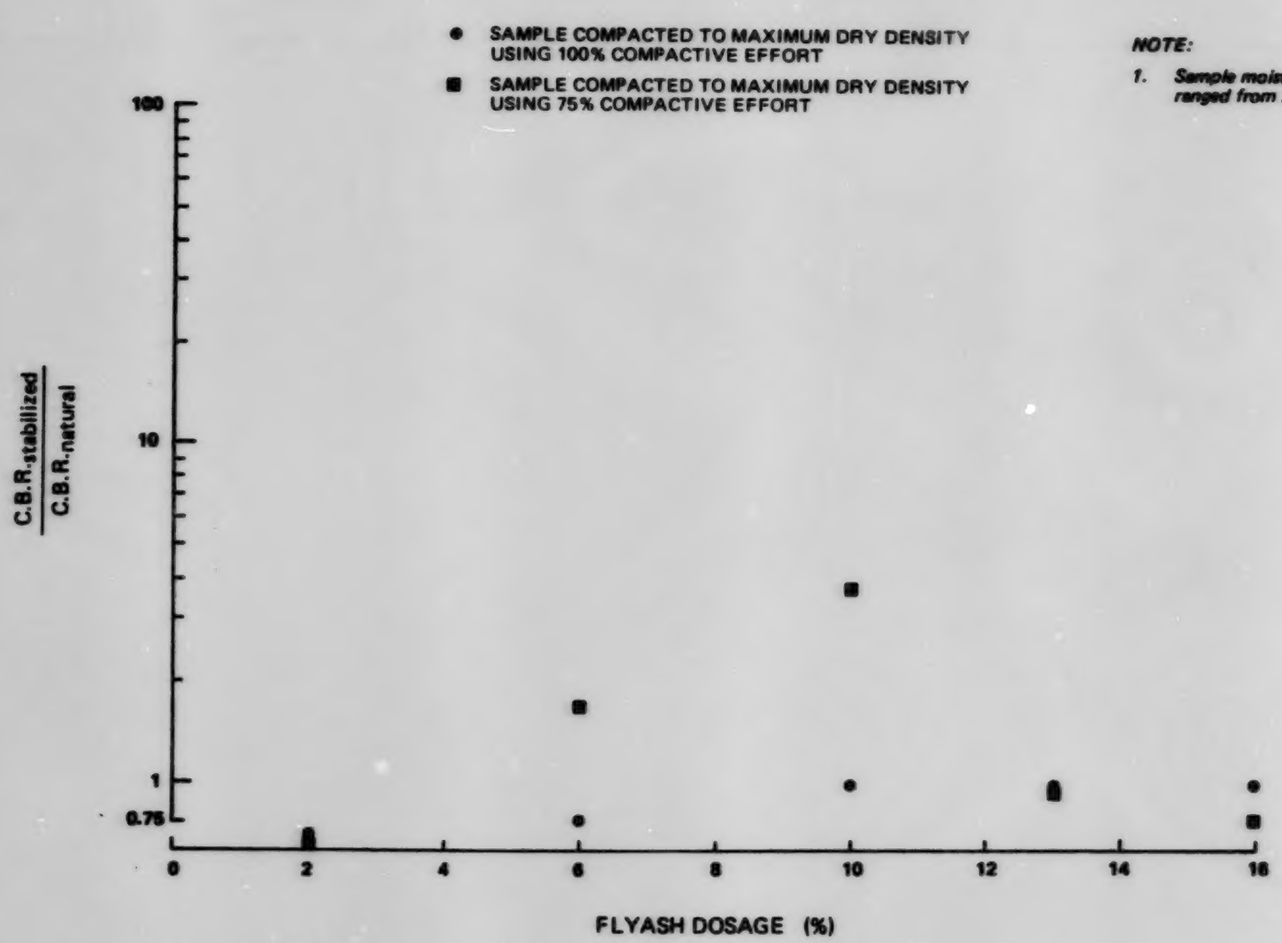


FIGURE 24 VARIATION OF CALIFORNIA BEARING RATIO WITH FUJIBETON DOSAGE SAMPLE – PINCHER CREEK



NOTE:

1. Sample moisture contents ranged from 21.2% to 37.5%.

FIGURE 25 VARIATION OF CALIFORNIA BEARING RATIO WITH FLYASH DOSAGE
SAMPLE: PINCHER CREEK

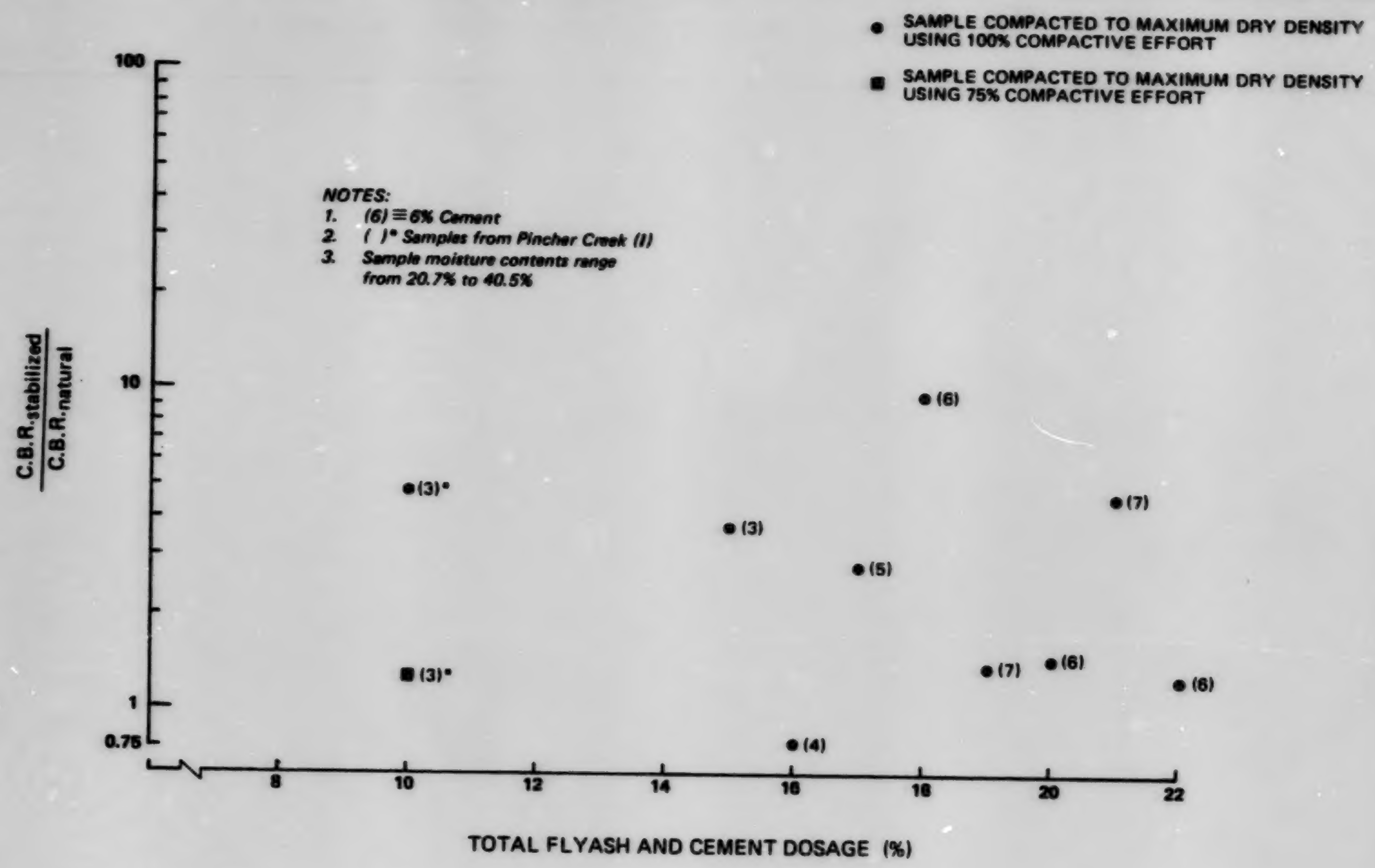


FIGURE 28 VARIATION OF CALIFORNIA BEARING RATIO WITH FLYASH AND CEMENT DOSAGE
SAMPLE: PINCHER CREEK II

GRAIN SIZE DISTRIBUTION

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Drumheller

Sand 1% , Silt 30% , Clay 69%

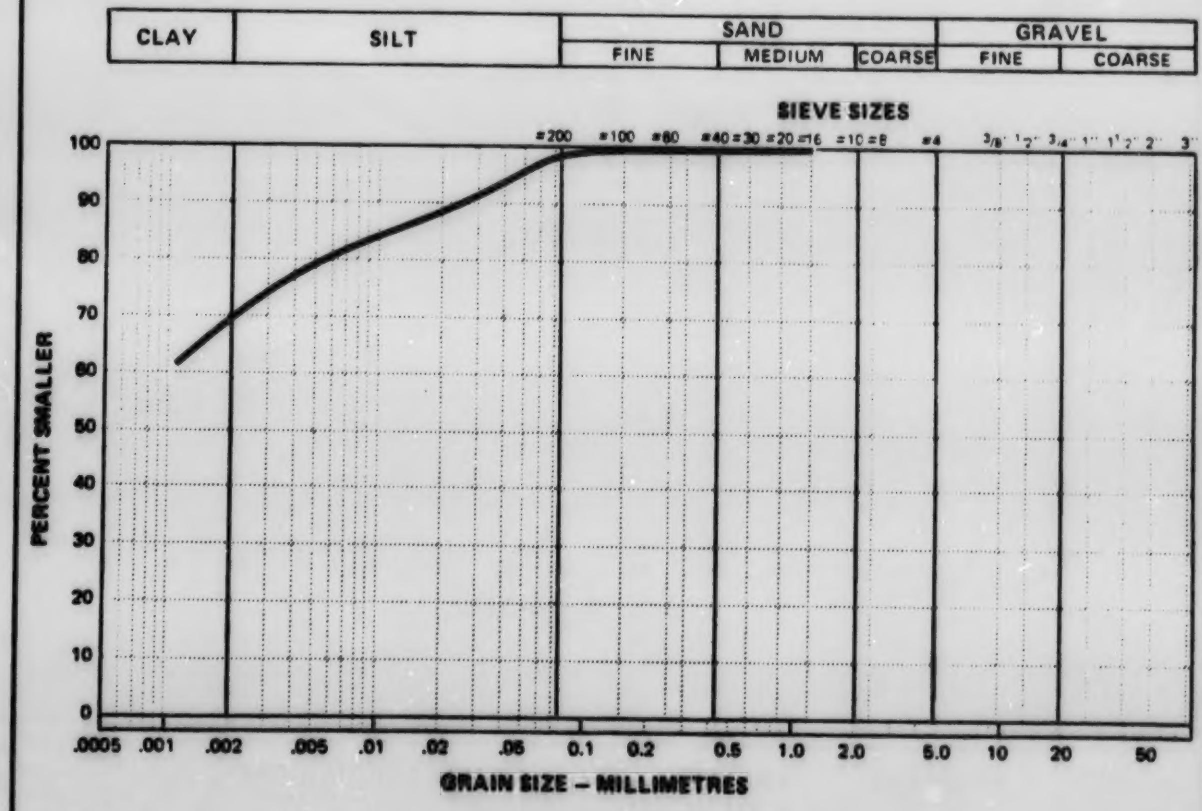


FIGURE 27

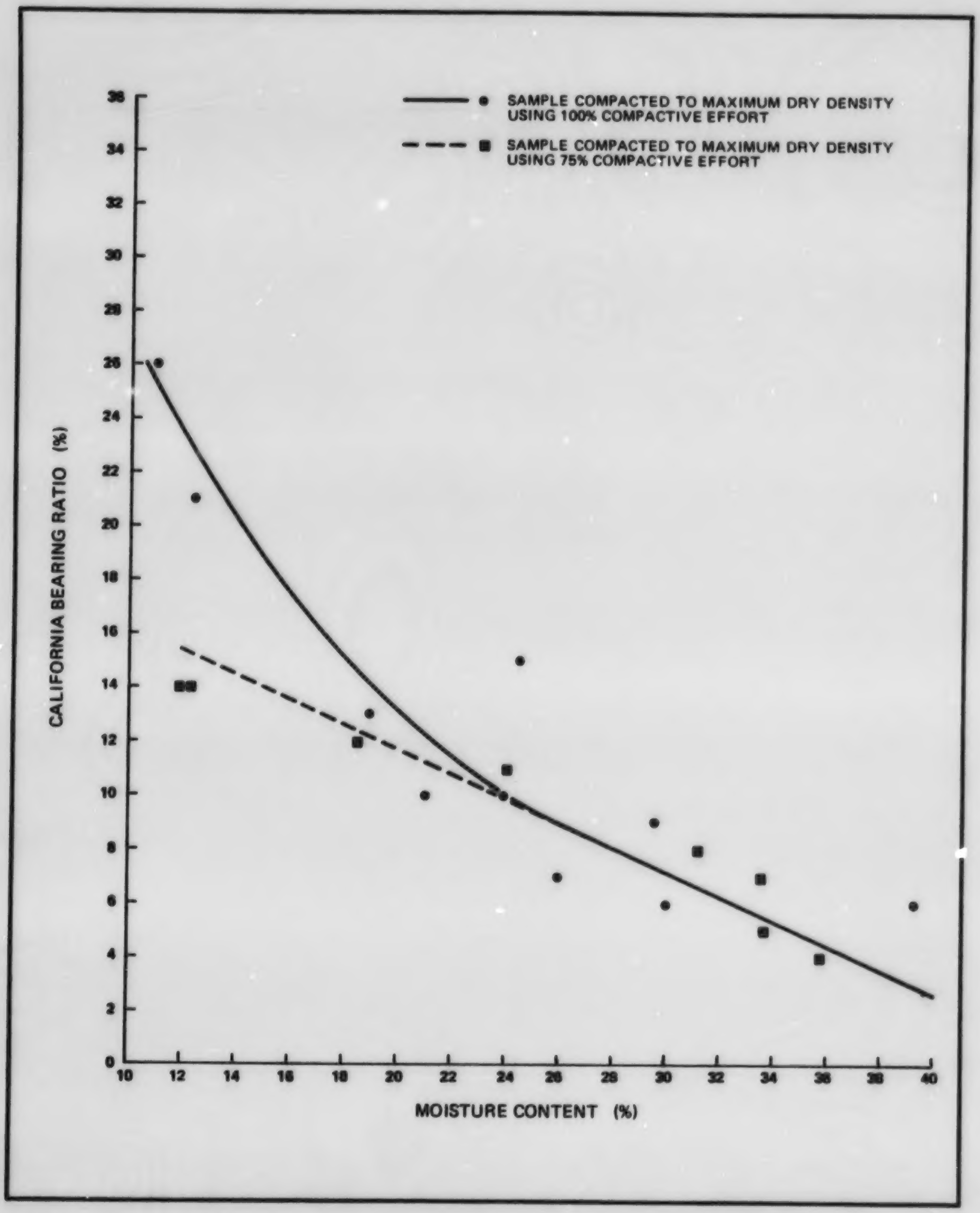


FIGURE 28 VARIATION OF CALIFORNIA BEARING RATIO WITH MOISTURE CONTENT SAMPLE – DRUMHELLER

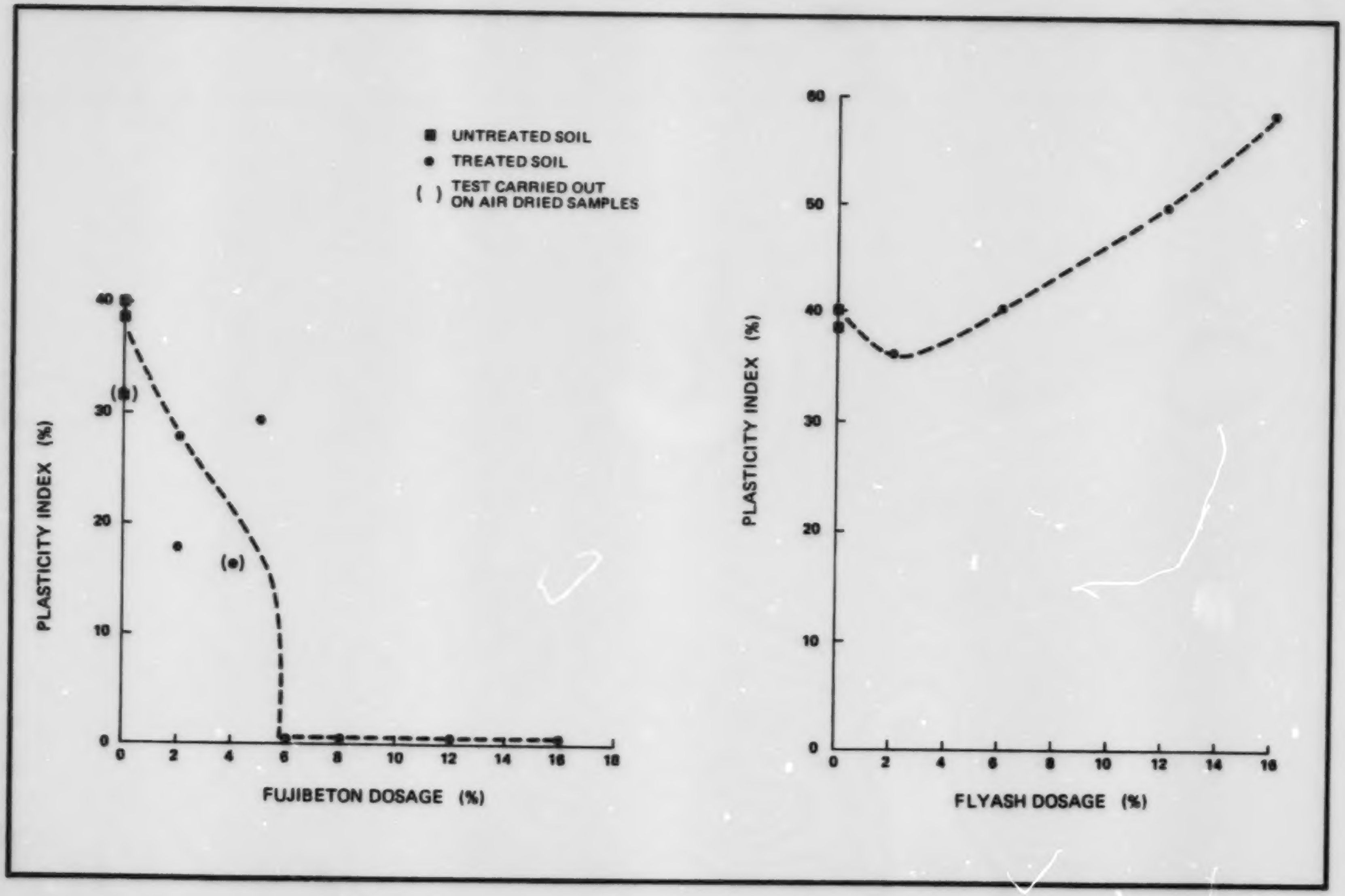
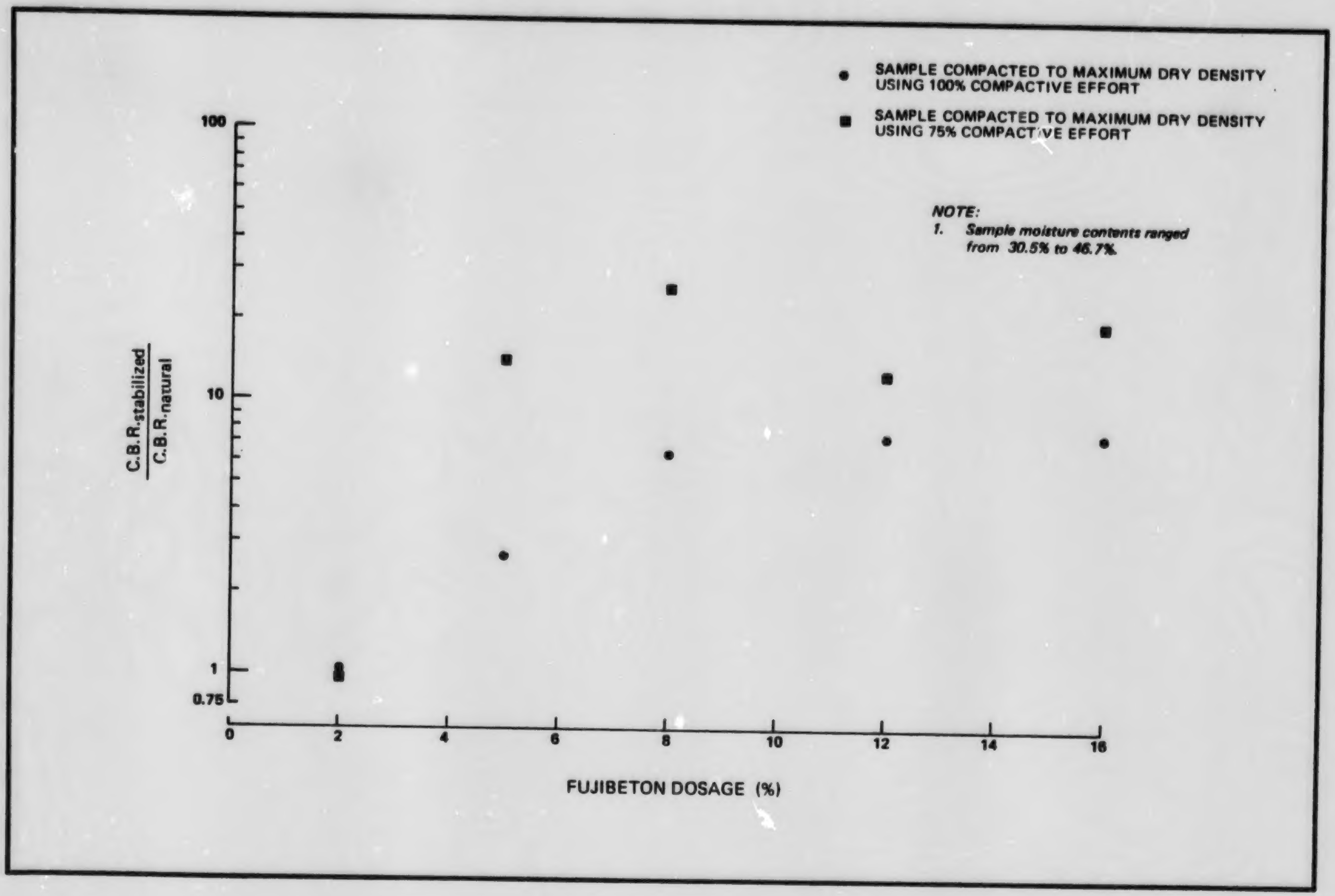


FIGURE 29 VARIATION OF PLASTICITY INDEX WITH STABILIZER DOSAGE 24 HOURS AFTER MIXING SAMPLE – DRUMHELLER



NOTE:
1. Sample moisture contents ranged from 30.5% to 46.7%.

FIGURE 30 VARIATION OF CALIFORNIA BEARING RATIO WITH FUJIBETON DOSAGE SAMPLE – DRUMHELLER

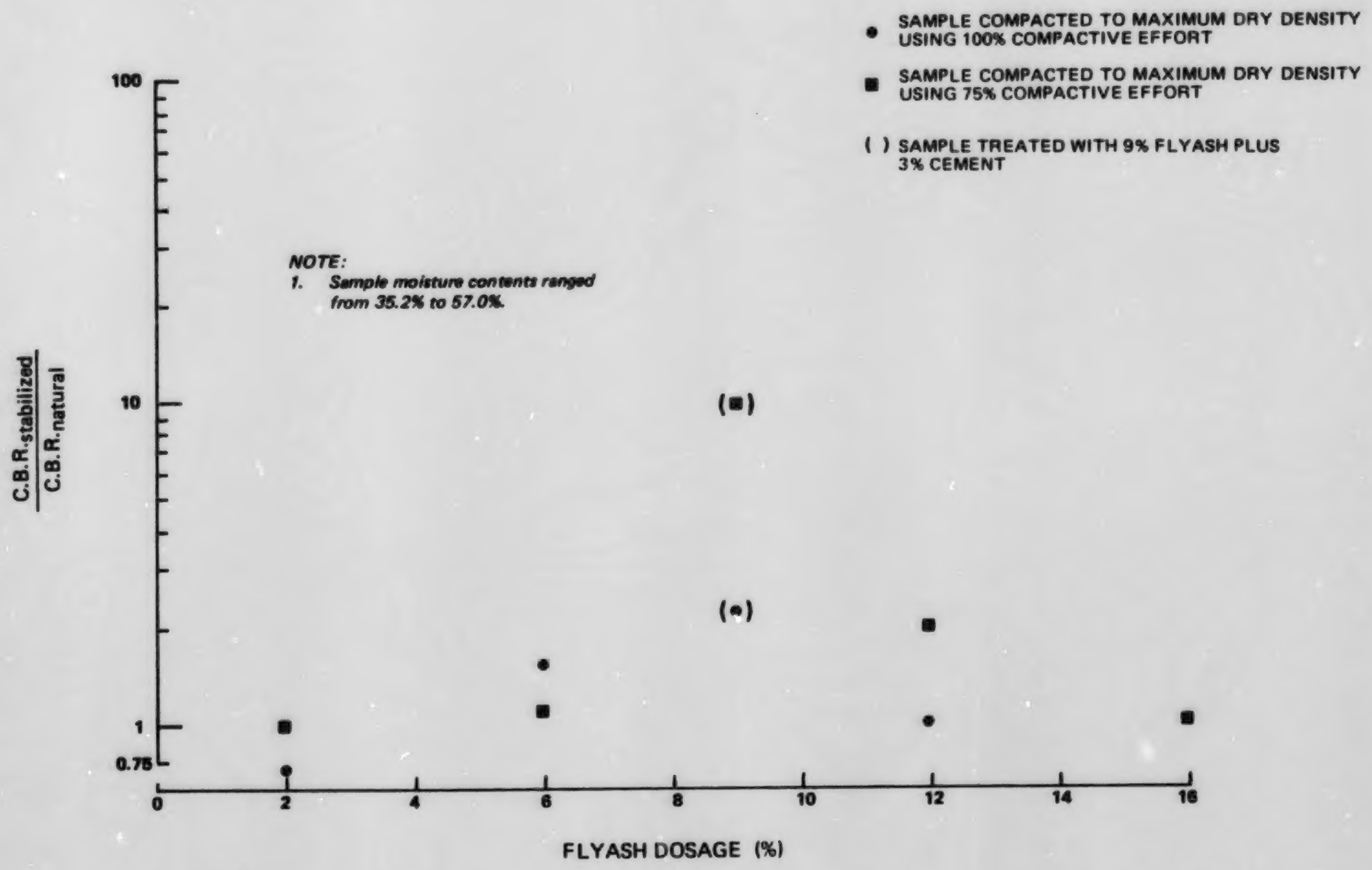


FIGURE 31 VARIATION OF CALIFORNIA BEARING RATIO WITH FLYASH DOSAGE
SAMPLE: DRUMHELLER

GRAIN SIZE DISTRIBUTION

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA Contract No.: 1 SD 83-00026

Project No.: 314 - 1264.02

Sample: Bashaw

Sand 91%, Silt 7%, Clay 2%

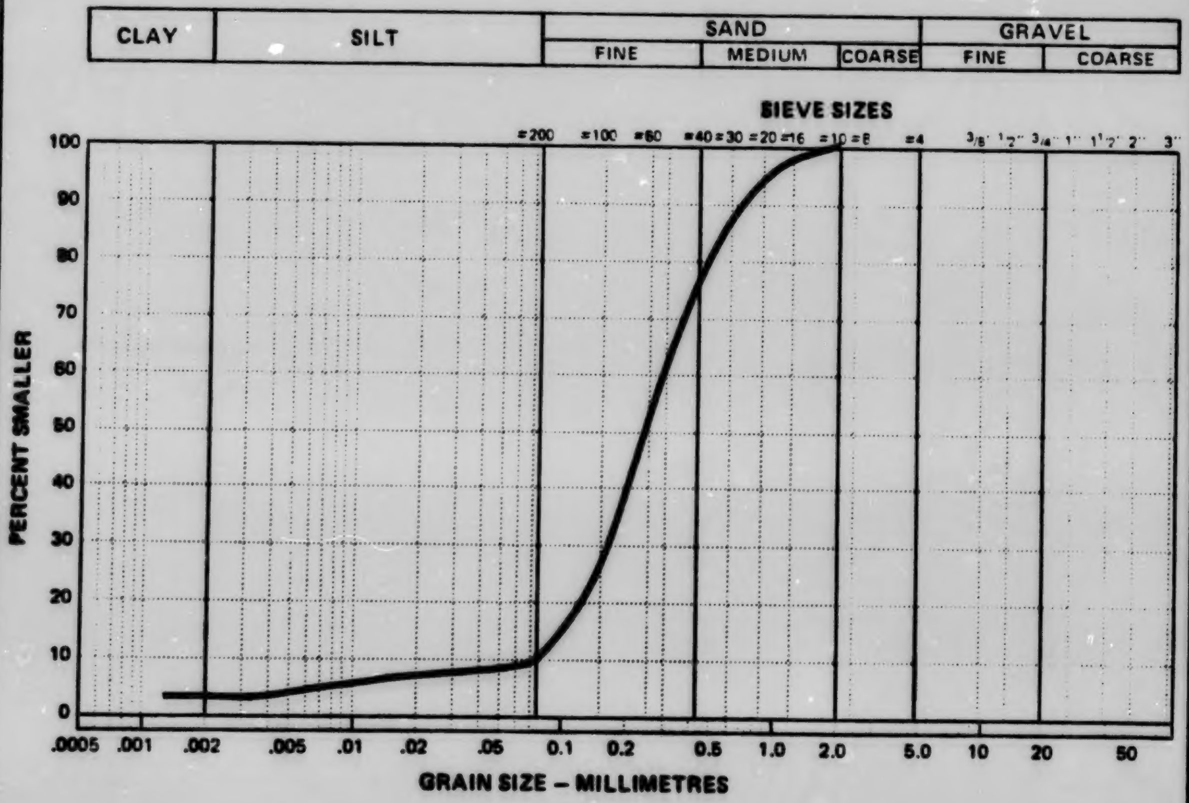


FIGURE 32

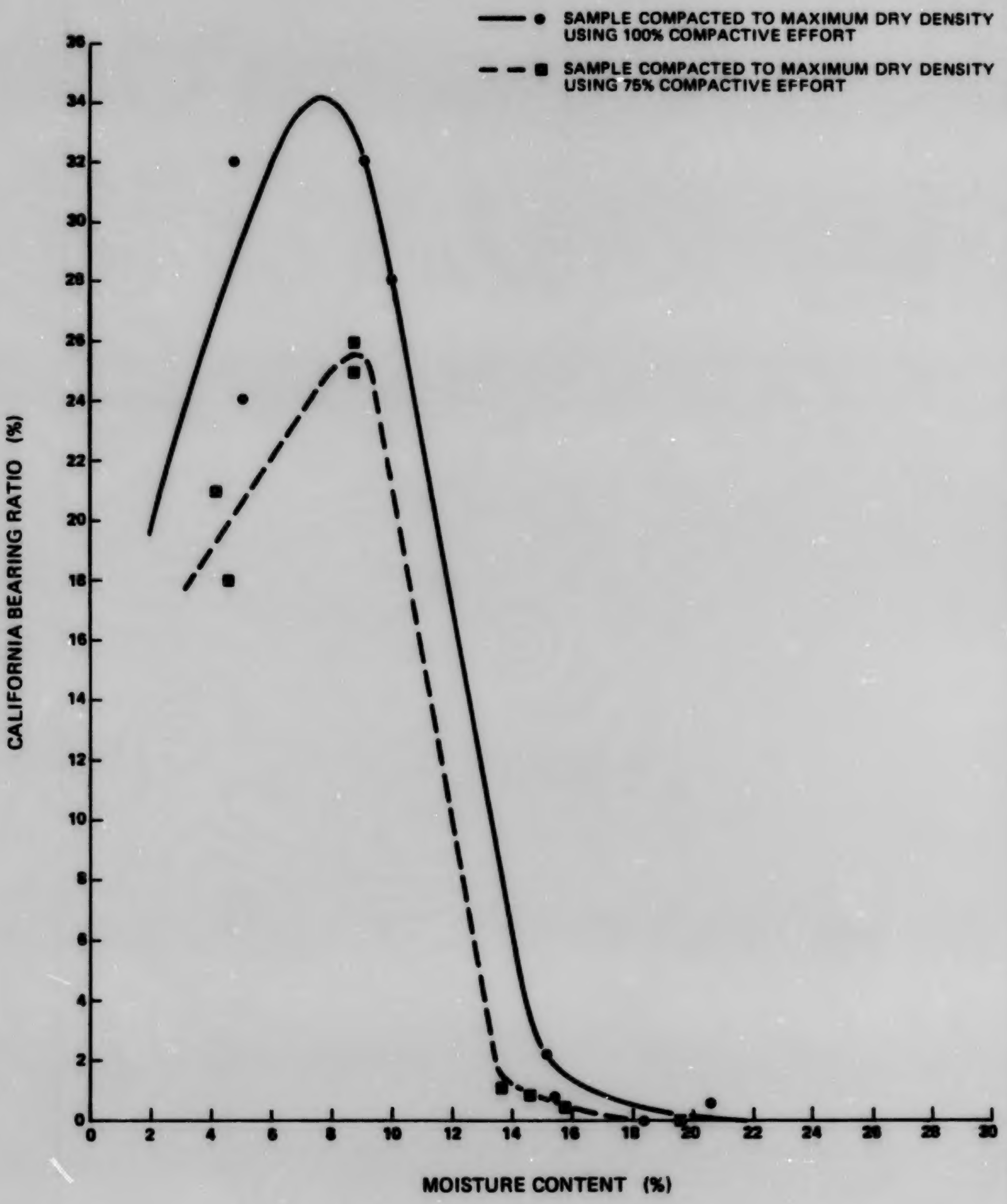
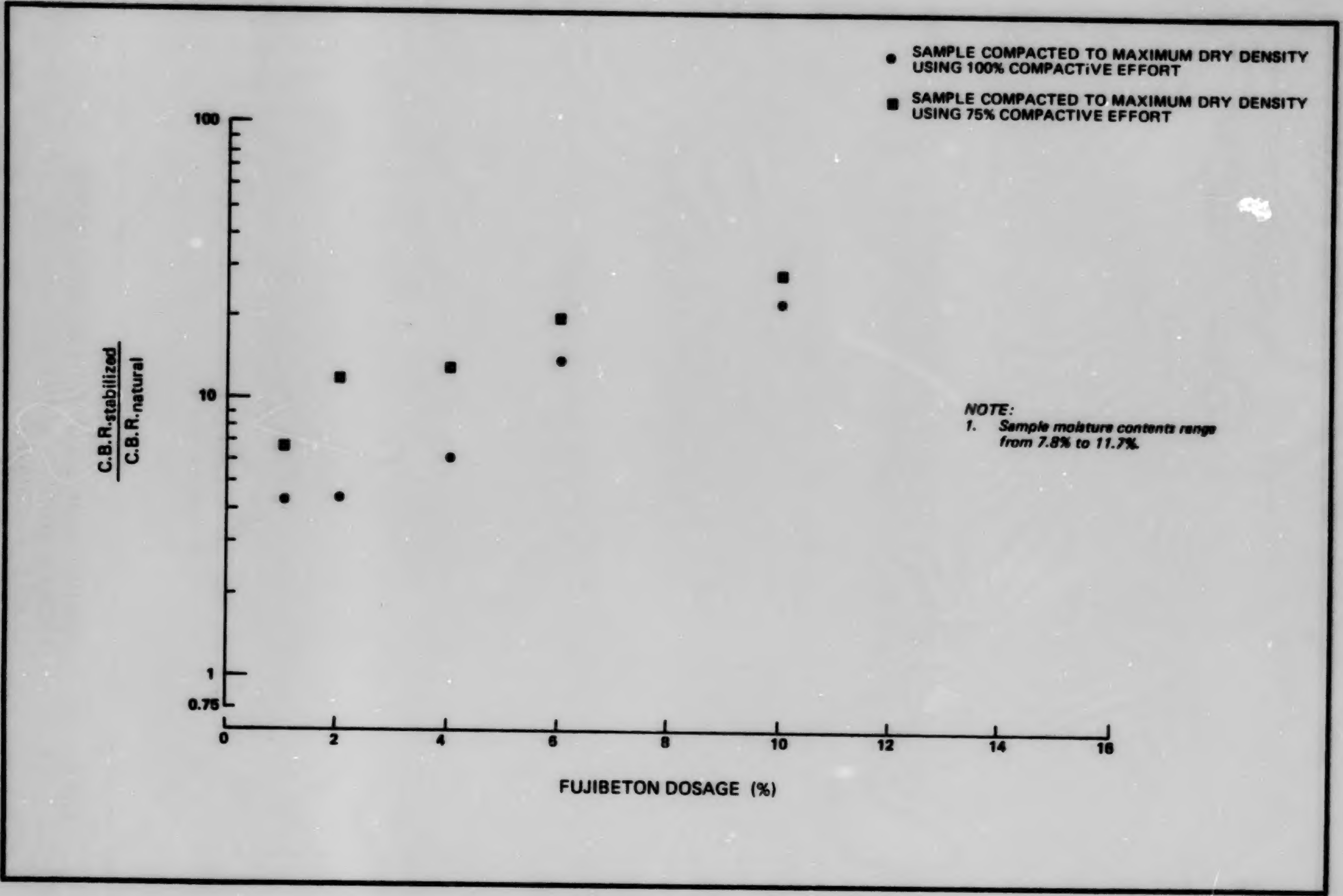
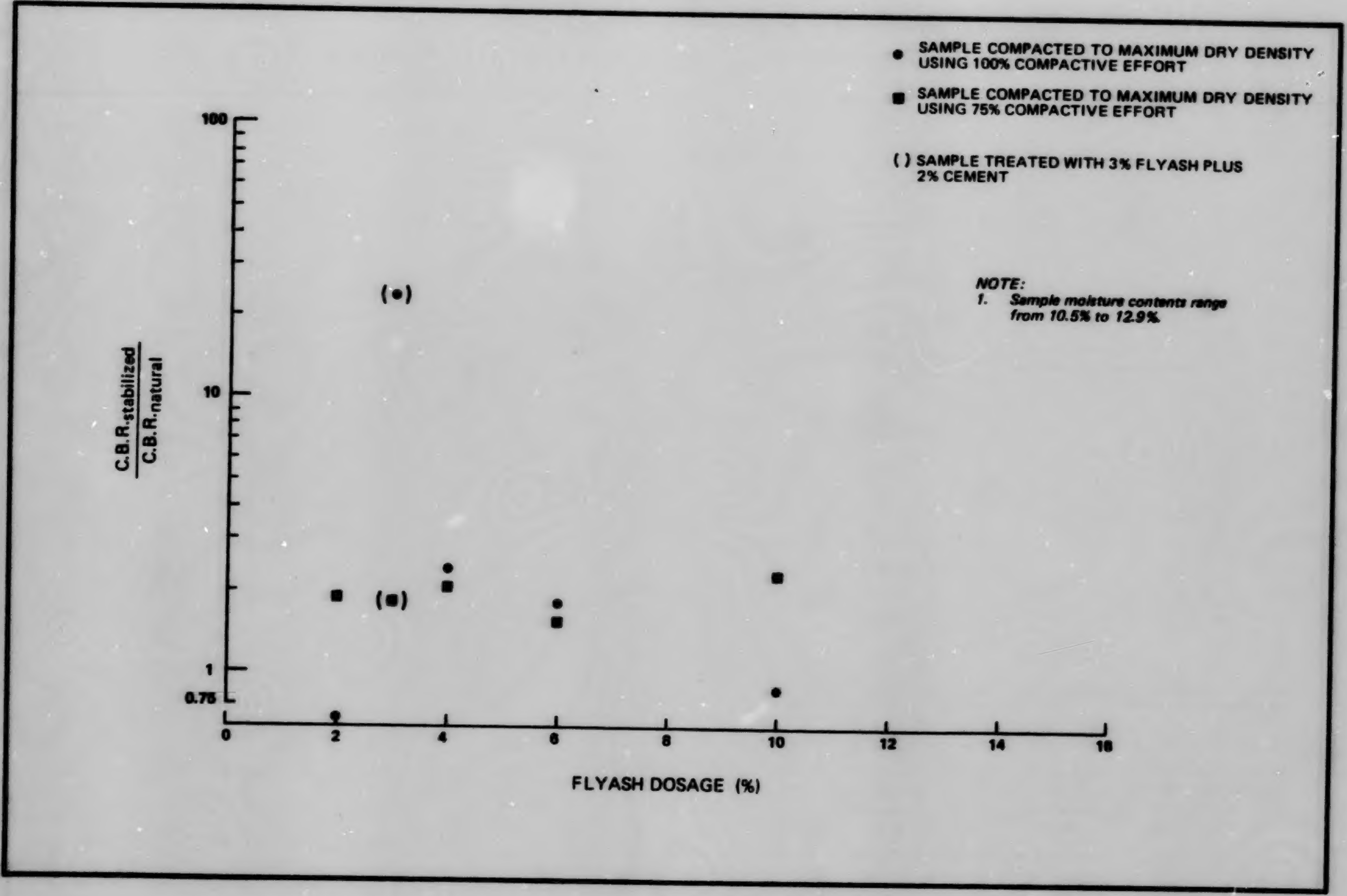


FIGURE 33 VARIATION OF CALIFORNIA BEARING RATIO WITH MOISTURE CONTENT SAMPLE – BASHAW



NOTE:
1. Sample moisture contents range from 7.8% to 11.7%.

FIGURE 34 VARIATION OF CALIFORNIA BEARING RATIO WITH FUJIBETON DOSAGE
SAMPLE: BASHAW



NOTE:
1. Sample moisture contents range from 10.5% to 12.9%.

FIGURE 35 VARIATION OF CALIFORNIA BEARING RATIO WITH FLYASH DOSAGE
SAMPLE: BASHAW

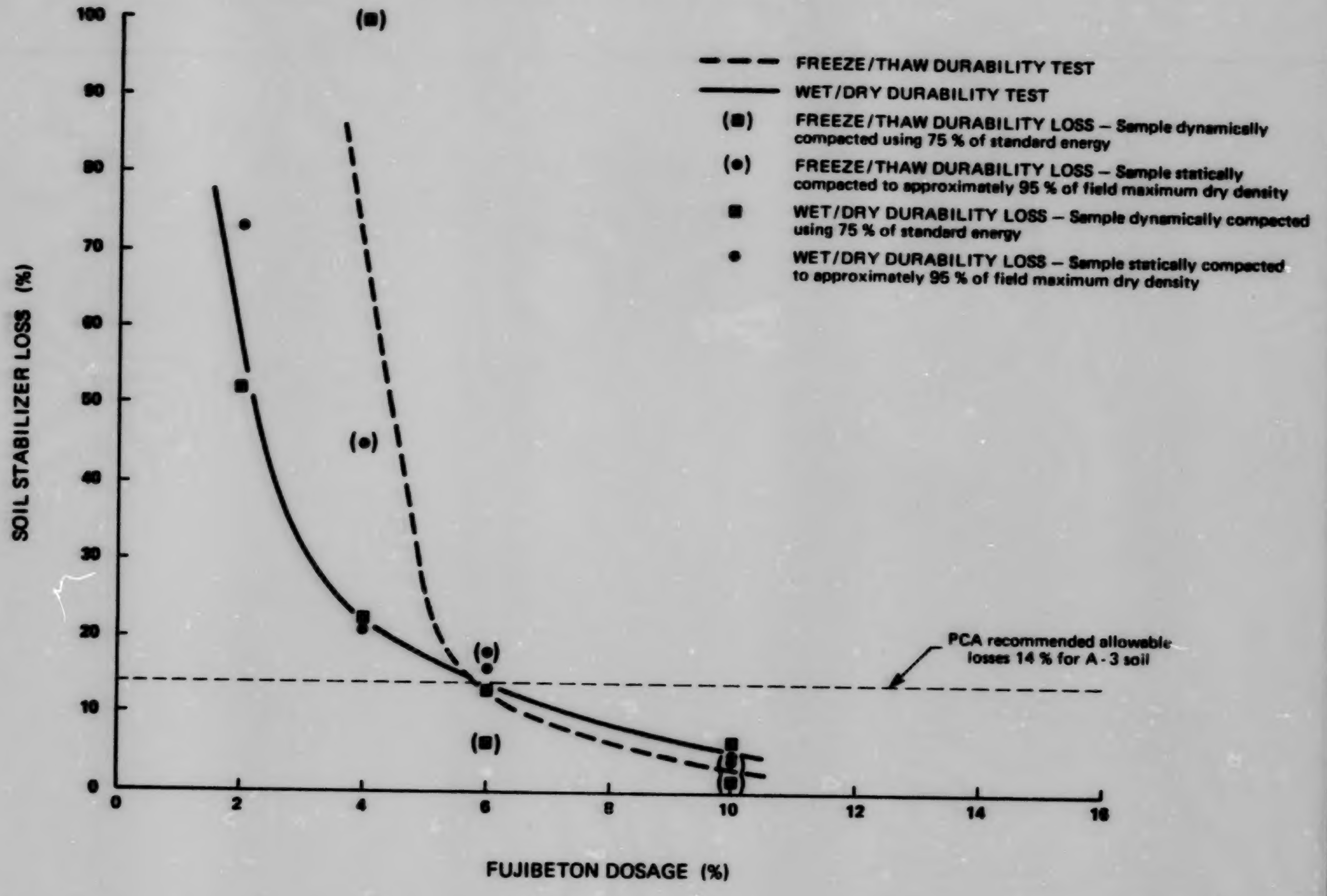


FIGURE 36 VARIATION OF SOIL STABILIZER LOSSES WITH FUJIBETON DOSAGE AFTER DURABILITY TESTS SAMPLE – BASHAW

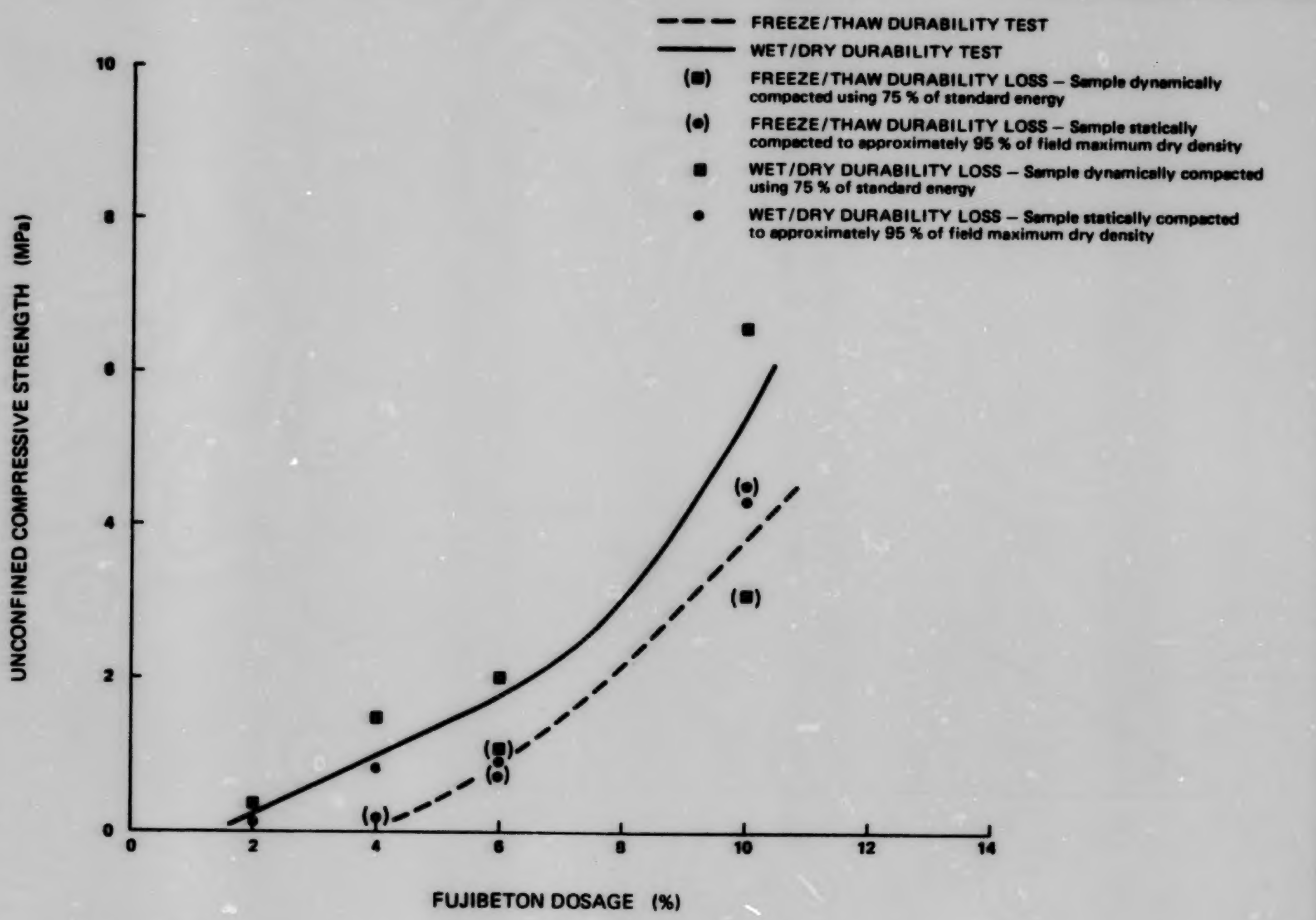


FIGURE 37 VARIATION OF UNCONFINED COMPRESSIVE STRENGTH WITH FUJIBETON DOSAGE AFTER DURABILITY TESTS SAMPLE – BASHAW

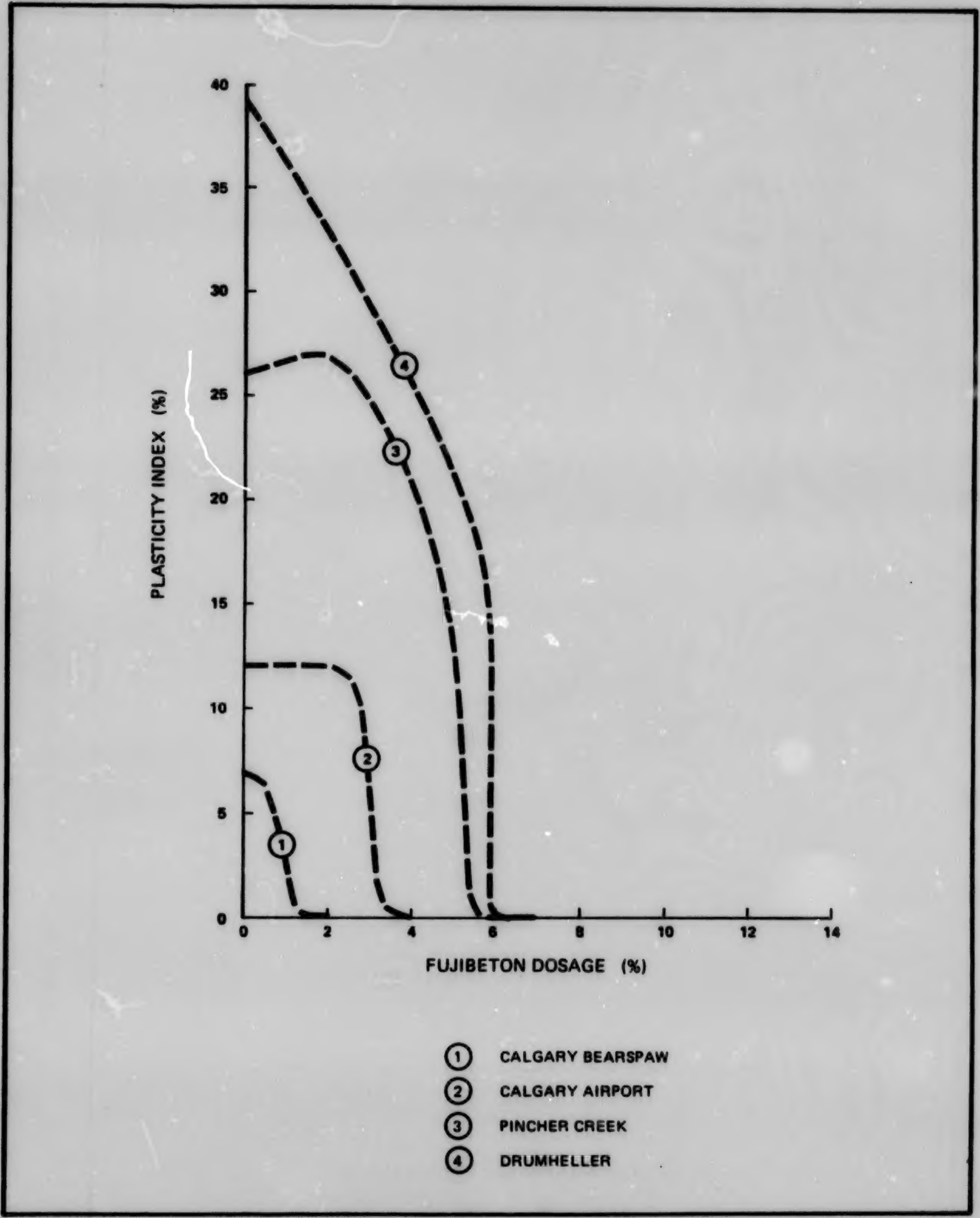


FIGURE 38 VARIATION OF PLASTICITY INDEX WITH FUJIBETON DOSAGE 24 HOURS AFTER MIXING

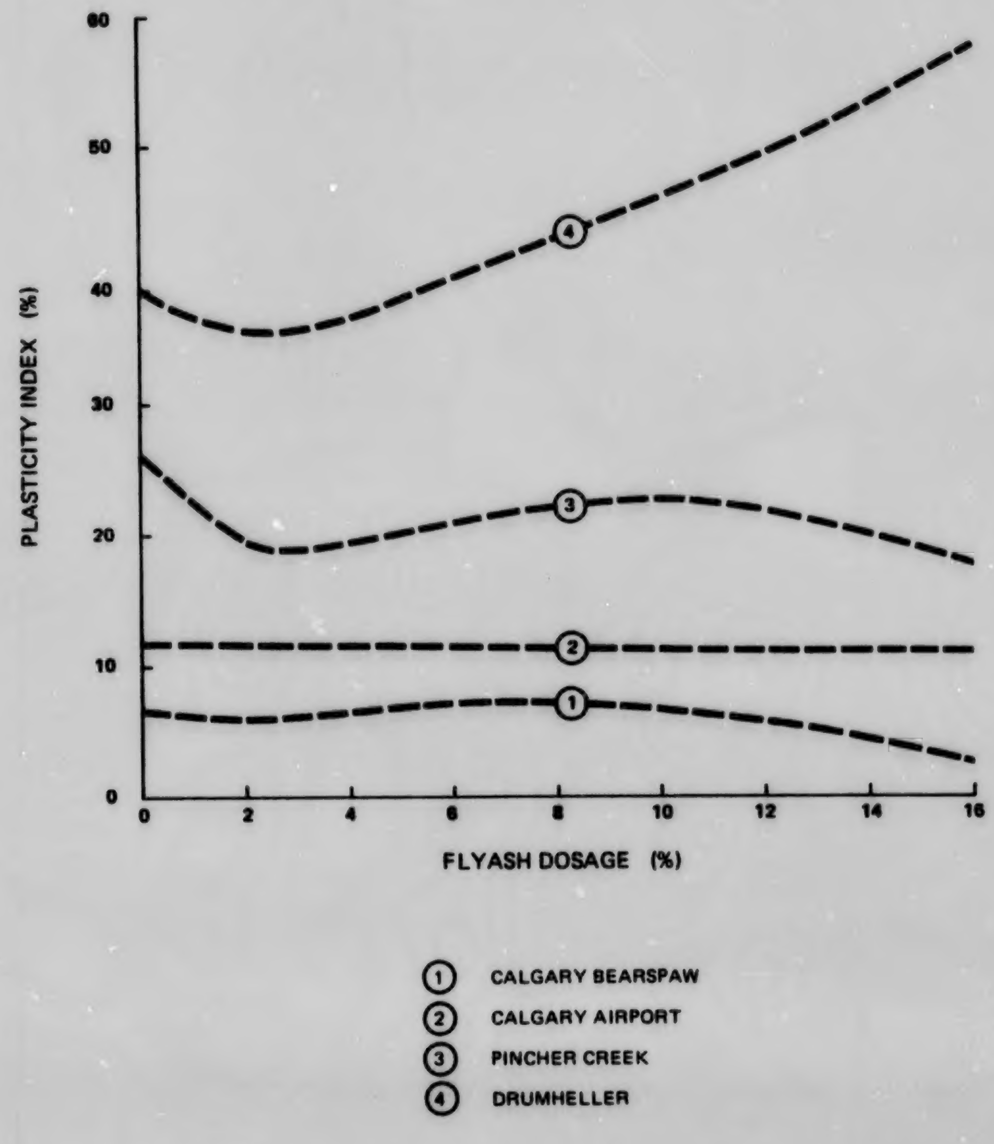
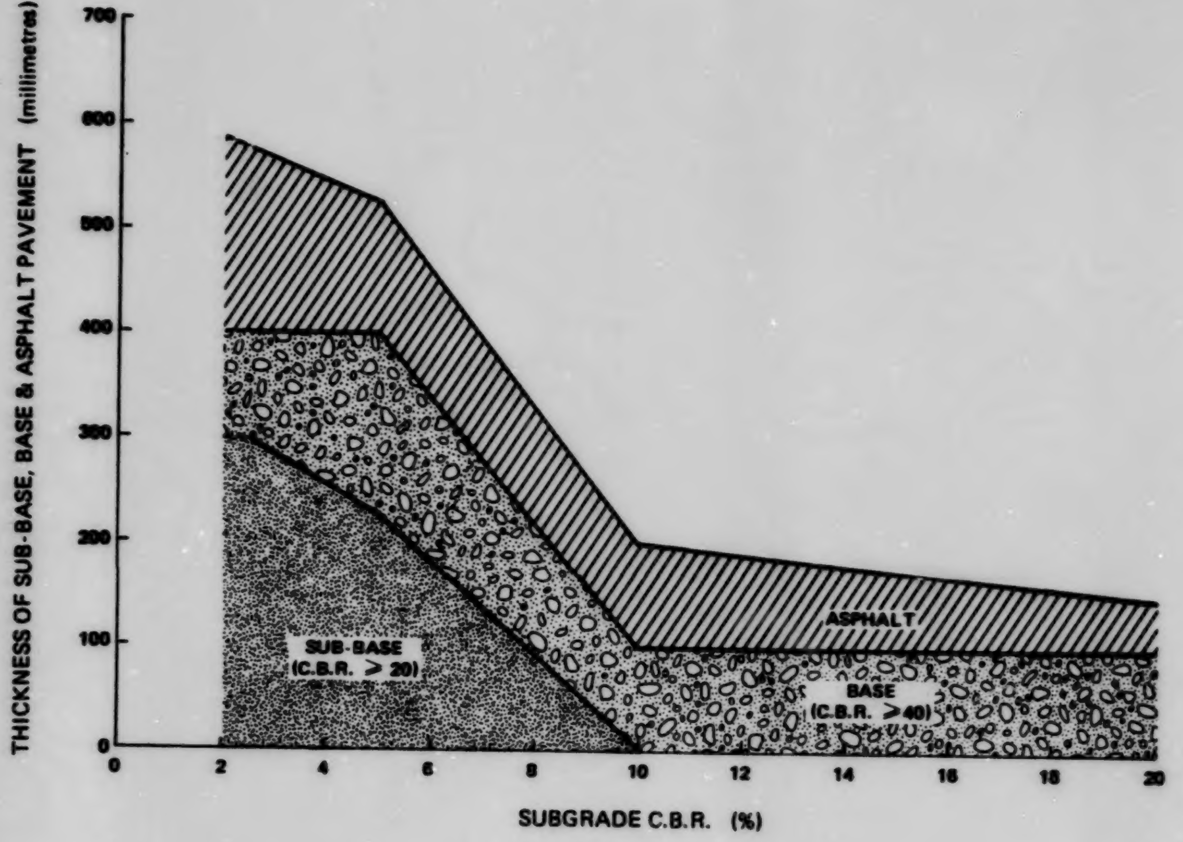
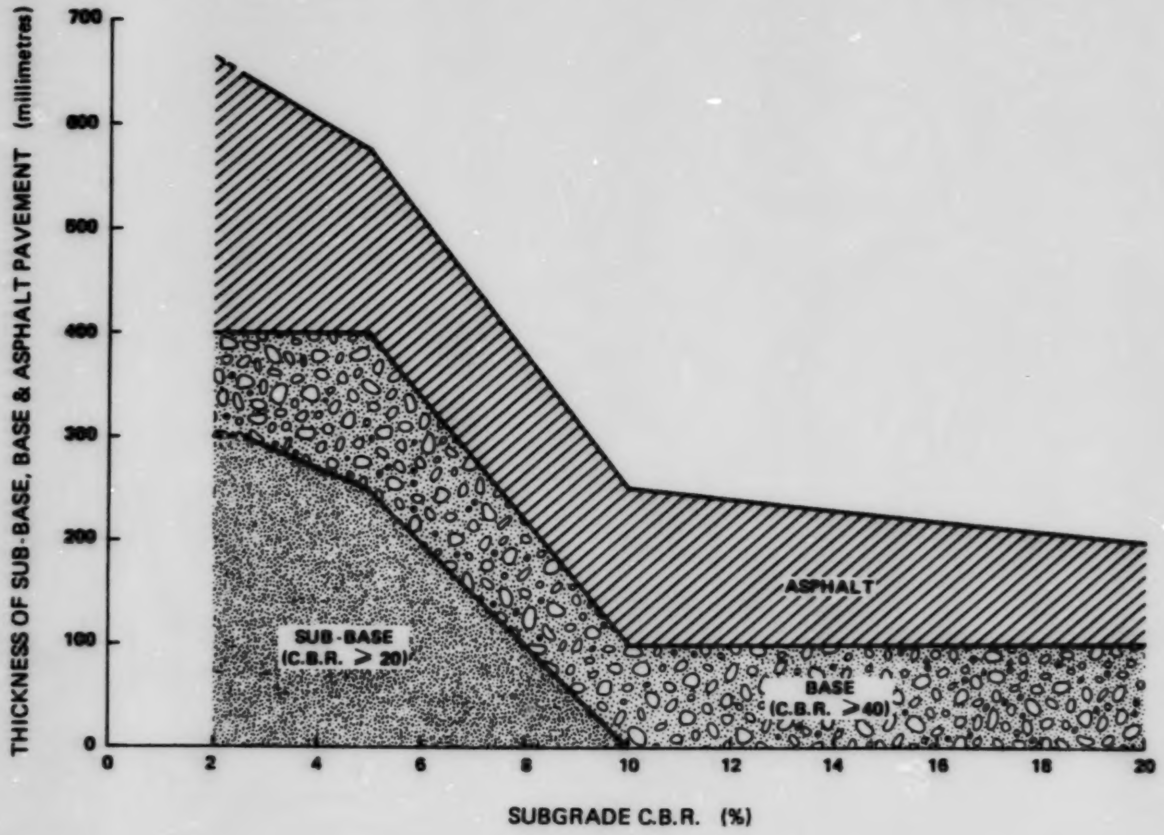


FIGURE 39 VARIATION OF PLASTICITY INDEX WITH FLYASH DOSAGE 24 HOURS AFTER MIXING



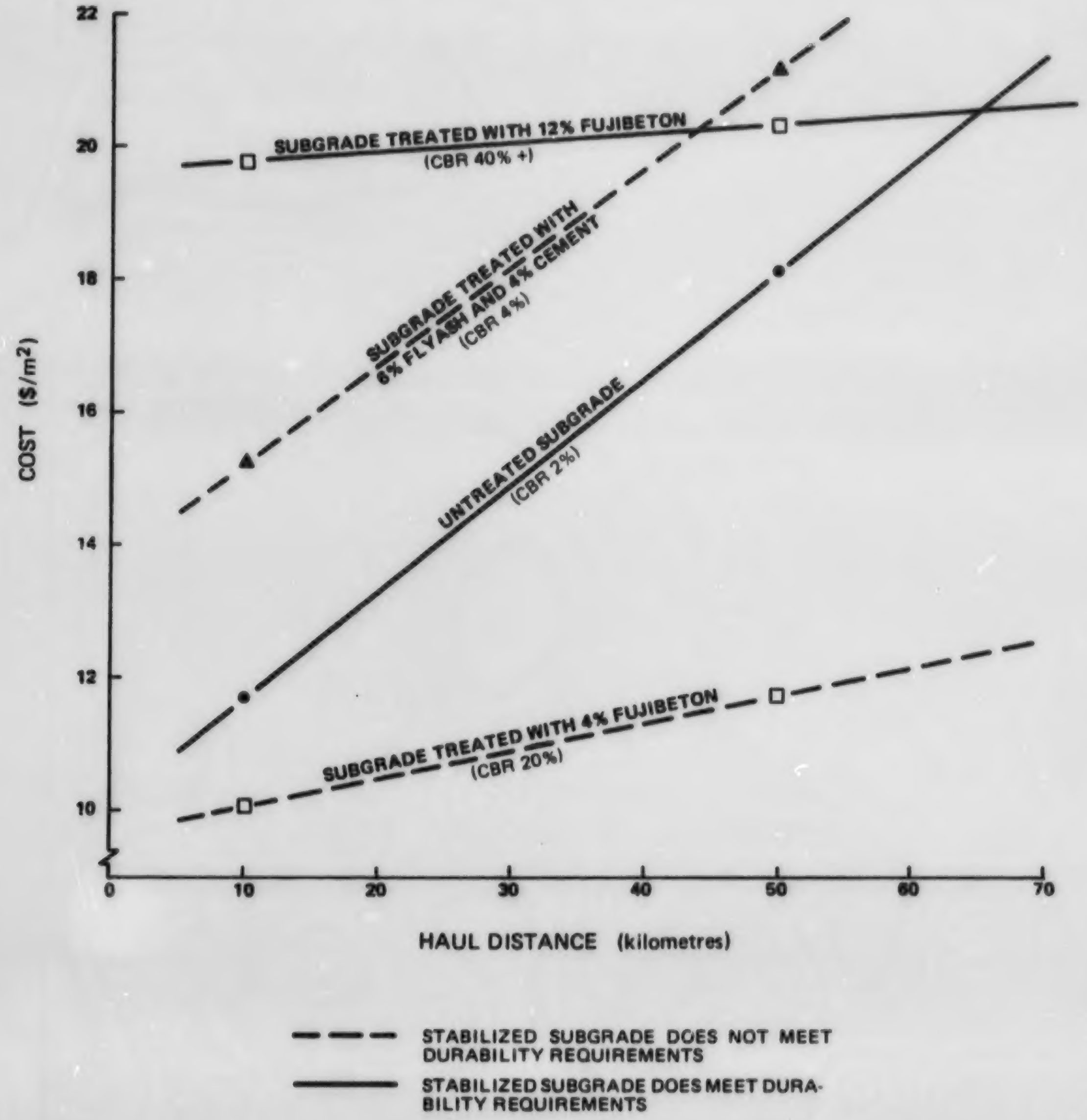
FROM SHELL DESIGN CHARTS (Ref. 16)

FIGURE 40 ROAD CONSTRUCTION MATERIAL REQUIREMENTS vs. SUBGRADE C.B.R.
TRAFFIC LOAD: 7.5×10^5 ESAL'S



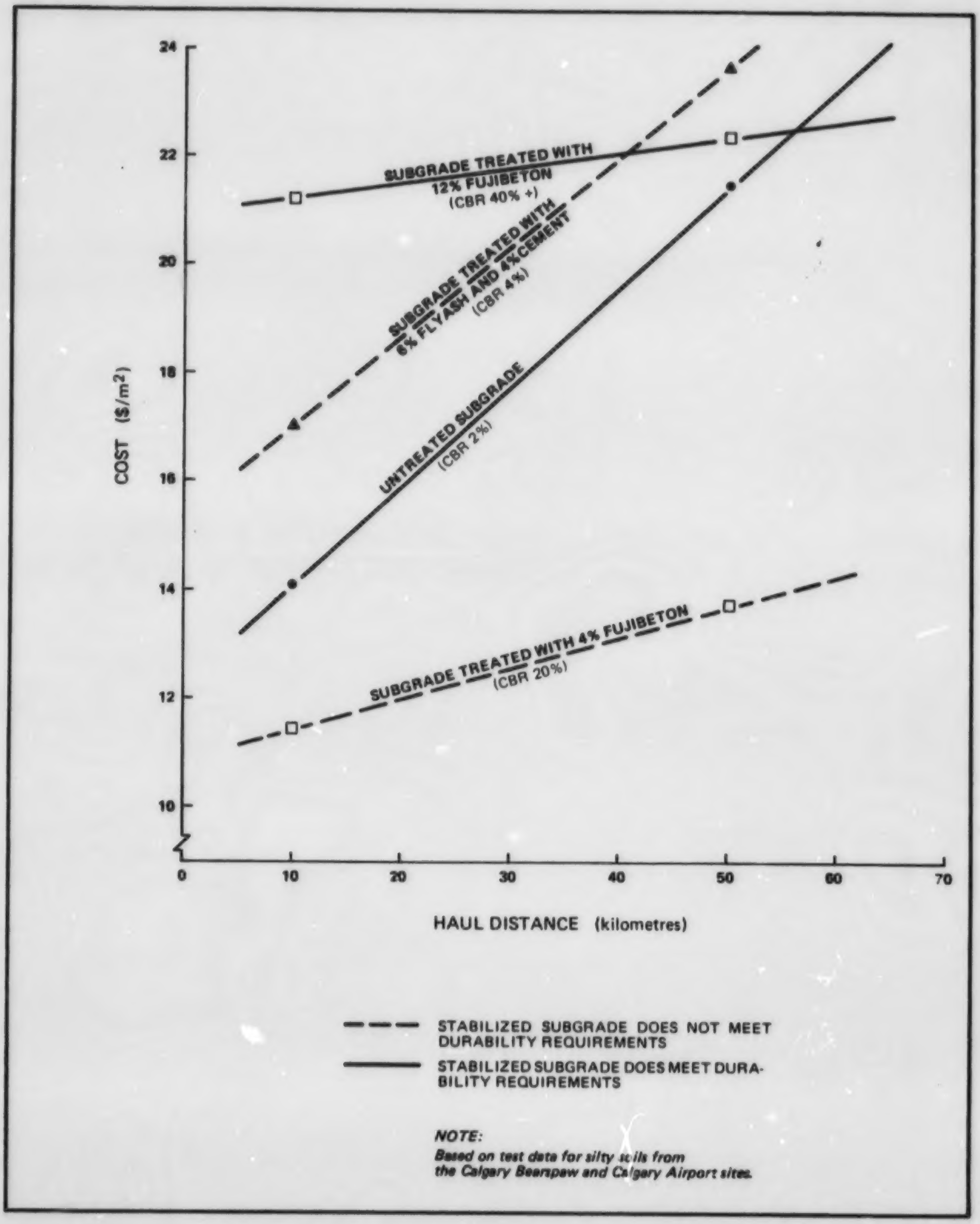
FROM SHELL DESIGN CHARTS (Ref. 16)

FIGURE 41 ROAD CONSTRUCTION MATERIAL REQUIREMENTS vs. SUBGRADE C.B.R.
TRAFFIC LOAD: 3.0×10^6 ESAL'S



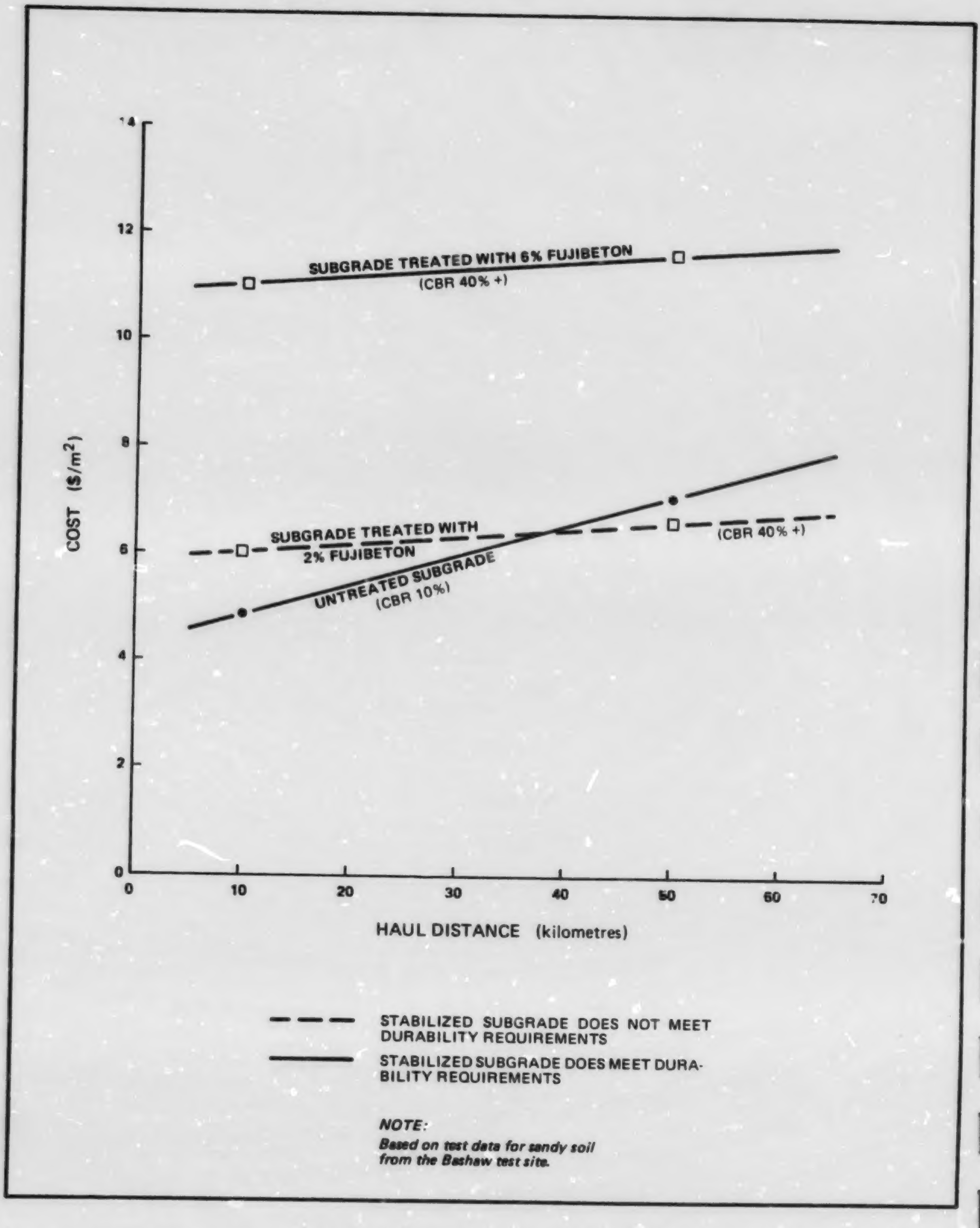
NOTE:
Based on test data for silty soils from the Calgary Bearspaw and Calgary Airport sites.

FIGURE 42 COST COMPARISON BETWEEN ROAD CONSTRUCTION ON SILTY SUBGRADE AND ON STABILIZER TREATED SUBGRADE TRAFFIC LOAD: 7.5 x 10^5 ESAL'S



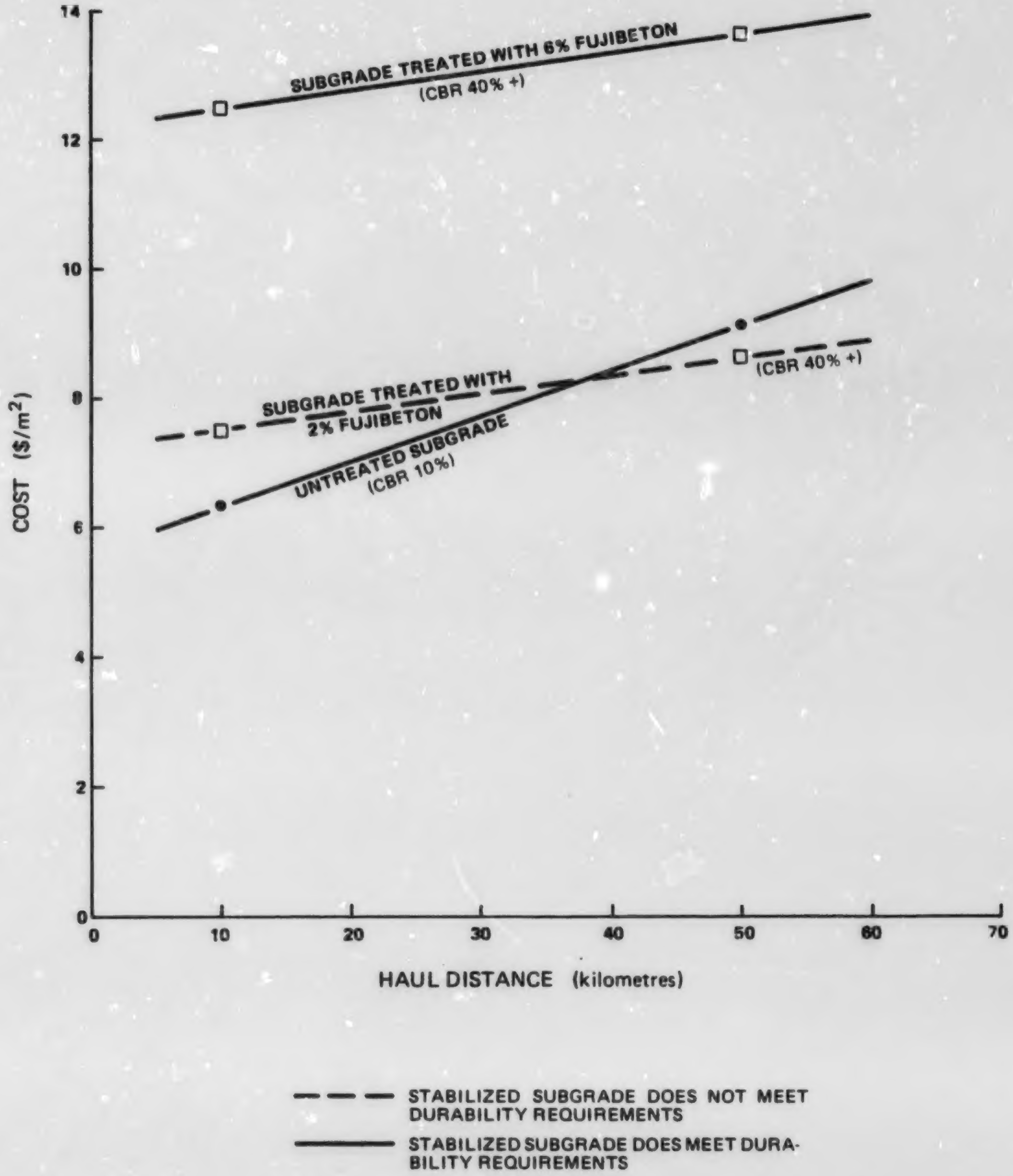
NOTE:
Based on test data for silty soils from the Calgary Bearspaw and Calgary Airport sites.

FIGURE 43 **COST COMPARISON BETWEEN ROAD CONSTRUCTION ON SILTY SUBGRADE AND ON STABILIZER TREATED SUBGRADE TRAFFIC LOAD: 3.0×10^6 ESAL'S**



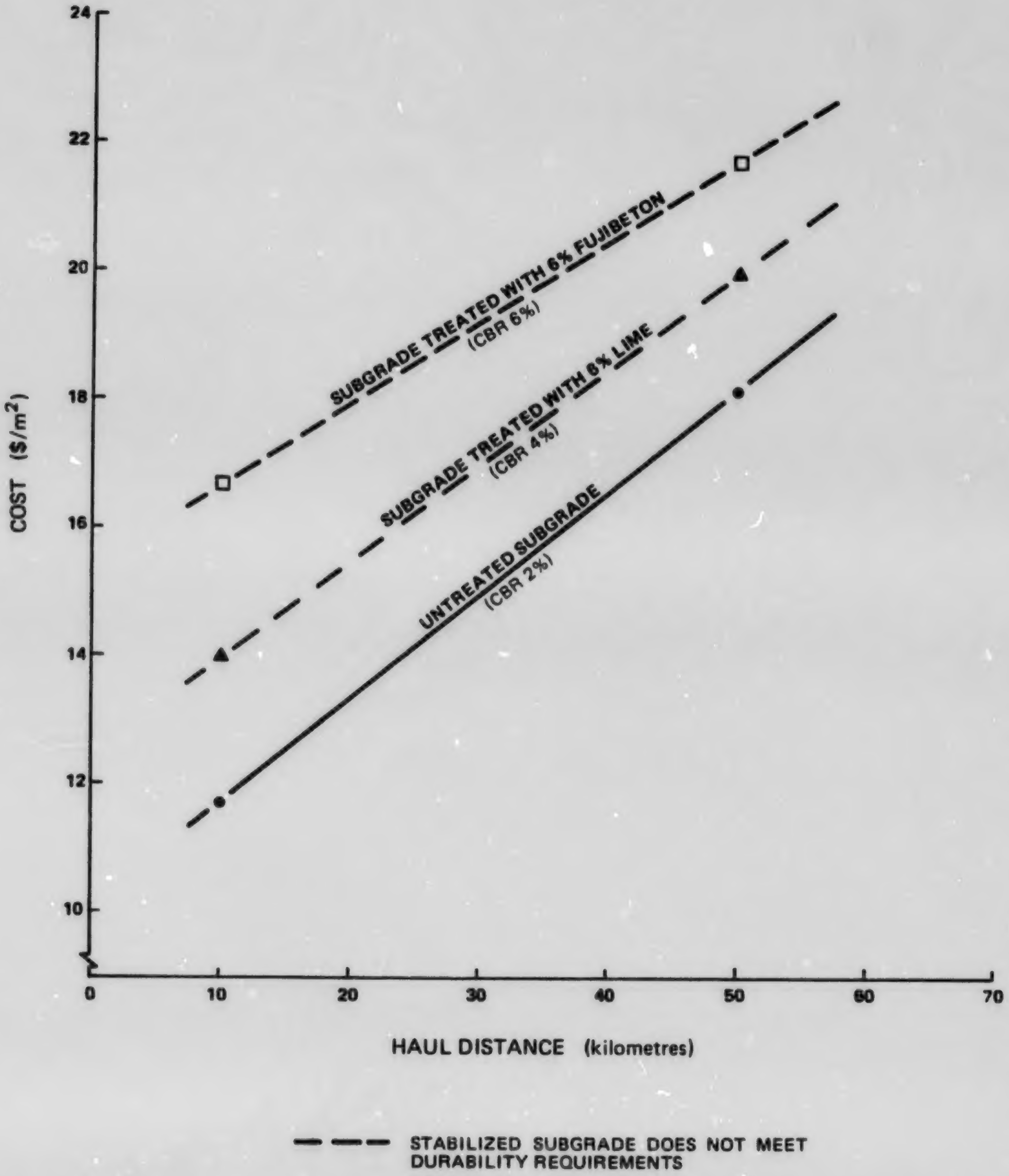
NOTE:
Based on test data for sandy soil from the Bashaw test site.

FIGURE 44 COST COMPARISON BETWEEN ROAD CONSTRUCTION ON SANDY SUBGRADE AND ON STABILIZER TREATED SUBGRADE TRAFFIC LOAD: 7.5 x 10^5 ESAL'S



NOTE:
Based on test data for sandy soil from the Bashaw site.

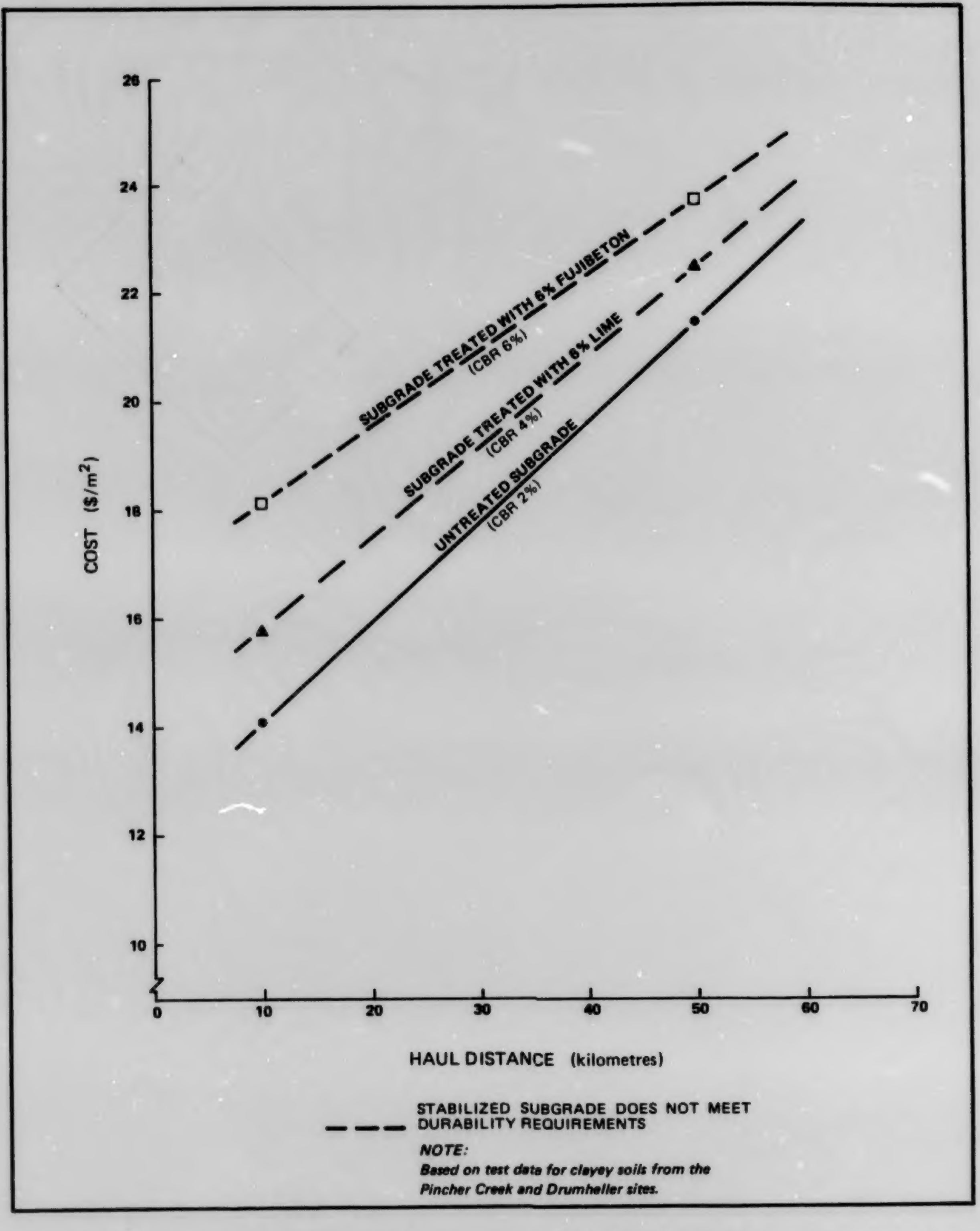
FIGURE 45 COST COMPARISON BETWEEN ROAD CONSTRUCTION ON SANDY SUBGRADE AND ON STABILIZER TREATED SUBGRADE TRAFFIC LOAD: 3.0×10^6 ESAL'S



NOTE:

Based on test data for clayey soils from the Pincher Creek and Drumheller sites.

FIGURE 46 COST COMPARISON BETWEEN ROAD CONSTRUCTION ON CLAYEY SUBGRADE AND ON STABILIZER TREATED SUBGRADE TRAFFIC LOAD: 7.5 x 10^5 ESAL'S



NOTE:
Based on test data for clayey soils from the Pincher Creek and Drumheller sites.

FIGURE 47 COST COMPARISON BETWEEN ROAD CONSTRUCTION ON CLAYEY SUBGRADE AND ON STABILIZER TREATED SUBGRADE TRAFFIC LOAD: 3.0 x 10^6 ESAL'S

Number/
Numéro

3

LABORATORY EVALUATION OF FLYASH CEMENT AND LIGNIN CELLULOSE CEMENT AS SOIL STABILIZERS

VOLUME II OF II

Prepared for:

TRANSPORTATION DEVELOPMENT CENTRE

MARCH 1984

EBA Engineering Consultants Ltd.
MATERIALS ENGINEERING GROUP

314-1264-02

TP 5287 E

LABORATORY EVALUATION OF FLYASH CEMENT AND LIGNIN CELLULOSE CEMENT AS SOIL STABILIZERS

VOLUME II OF II

Library and Information Centre
Centre de Do[illegible] (GSL)
[illegible] LE
RE[illegible]
SEP 10 1984
Government Publication Officielle
Transport Canada | Transports Canada

Prepared for:

TRANSPORTATION DEVELOPMENT CENTRE

by:

MICHAEL D. GRAHAM, P.ENG. AND C.B. DAWLEY, P.ENG.
EBA ENGINEERING CONSULTANTS LTD.

MARCH, 1984

"The contents of this report reflect the views of the contractor and not necessarily the official views or policies of the Transportation Development Centre".

REPORT DOCUMENTATION FORM

1. Transport Canada Report No. TP 5287E	2. TDC Project No. 4925,4926	3. Recipient's Catalogue No.

4. Title and Subtitle

Laboratory evaluation of flyash cement and lignin cellulose cement as soil stabilizers (2 volumes)

5. Report Date

March, 1984

6. Performing Organization Report No.

0304-31264-002

7. Author(s)

M.D. Graham and C.B. Dawley

8. Transport Canada File No.

D1465-413

9. Performing Organization Name and Address

EBA Engineering Consultants Ltd.
7175 - 12 Street S.E.
Calgary, Alberta T2H 2S6

10. DSS File No.

14SD.T8200-2-2582

11. DSS or Transport Canada Contract No.

1SD83-00026

12. Sponsoring Agency Name and Address

Transportation Development Centre
1000 Sherbrooke Street West
Suite 2421
Montreal Quebec H3A 2R3

Supply & Services Canada
88 Metcalfe Street
Ottawa, Ontario
K1A 0B5

13. Type of Report and Period Covered

Final Jun 83 - Feb 84

14. Sponsoring Agency Code

TDC 4925

15. Supplementary Notes

Summary report (TP 5288) is available in English and in French.

16. TDC Project Officer

Wayne Rowan

17. Abstract

An investigation was carried out to examine the effectiveness of lignin cellulose cement (trade name Fujibeton B), flyash, and flyash combined with cement as soil treatment agents. An extensive laboratory testing program was carried out on samples of fine grained soils treated with these agents. The soils comprised clayey, silty and sandy materials taken from five sites in southern Alberta, Canada, where problems related to soil volume change potential or frost susceptibility were known to exist. Laboratory testing included moisture density relations, index tests, strength tests and durability tests. The tests results indicate that Fujibeton B and flyash combined with cement can significantly improve the properties of fine sand, silt and clay relevant to earthworks design, whereas, the flyash examined (Battle River, Class F Ash) as sole treatment agent can improve soil properties only to a limited extent, if at all. A comparison of the effectiveness of the products identified above and cement or lime was developed from a review of the literature. Cost effectiveness data for the use of the soil treatment agents investigated was developed. The report concludes that Fujibeton B is effective as a stabilizer for silty and sandy soils and as a modifier of clayey soils and can be economical for use in earthworks construction where gravel and asphalt haulage distances are significant. Flyash combined with cement is effective as a stabilizer or modifier of silty and sandy soils but was not found to be economical for the case of secondary highway construction considered in this report.

18. Key Words

Soil Stabilization, Soil Modification, Soil Cement, Flyash, Lignin Cellulose, Earthworks Design, Frost Susceptibility, Volume Change Potential.

19. Distribution Statement

A limited number of copies are available from the Transportation Development Centre.

20. Security Classification (of this report) Unclassified	21. Security Classification (of this page) Unclassified	22. No. of Pages	23. Price

TDC CDT 79-005

FORMULE DE DOCUMENTATION POUR RAPPORT

1. **Nº du rapport Transports Canada**
TP 5287E

2. **Nº de l'étude — CDT**
4925, 4926

3. **Nº de catalogue du destinataire**

4. **Titre et sous-titre**
Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers (2 Volumes)

5. **Date du rapport**
mars 1984

6. **Nº du rapport de l'organisme exécutant**
0304-31264-002

7. **Auteur(s)**
M.D. Graham and C.B. Dawley

8. **Nº de dossier Transports Canada**
D1465-413

9. **Nom et adresse de l'organisme exécutant**
EBA Engineering Consultants Ltd.
7175 - 12 Street S.E.
Calgary, Alberta
T2H 2S6

10. **Nº de dossier — ASC**
14SD.T8200-2-2582

11. **Nº de contrat — ASC ou Transports Canada**
1SD83-00026

12. **Nom et adresse de l'organisme parrain**
Centre de développement des transports, Suite 2421
1000 ouest, rue Sherbrooke
Montréal, Québec H3A 2R3

Approvisionnements et services Canada
88 rue Metcalfe
Ottawa, Ontario K1A 0B5

13. **Genre de rapport et période visée**
Final; juin 83 - fév. 84

14. **Code de l'organisme parrain**
CDT 4925, 4926

15. **Remarques additionnelles**
Le rapport sommaire (TP 5288) est disponible en français et en anglais.

16. **Agent de projet — CDT**
W.G. Rowan

17. **Résumé**

Ce rapport rend compte des résultats d'une étude visant à déterminer l'efficacité des traitements de stabilisation des sols à l'aide de liants nouveaux, notamment un mélange ciment-lignocellulose (marque de fabrique: Fujibeton B), un mélange ciment-cendres volantes et des cendres volantes utilisées seules. Pour cela, un échantillonnage de sols à granulométrie fine a été traité au moyen de ces liants et soumis à un programme exhaustif d'essais et d'analyses en laboratoire. Les sols échantillonnés étaient des sols argileux, silteux et sablonneux, provenant de cinq sites différents du sud de l'Alberta, caractérisés par des problèmes d'instabilité volumique ou de sensibilité au gel. Ces essais en laboratoire avaient pour objet la détermination des relations teneur en eau-densité, des indices de plasticité, des indices de portance et de la durabilité. Les résultats indiquent que le Fujibeton B et les mélanges ciment-cendres volantes peuvent améliorer considérablement les propriétés géotechniques des sols sablonneux, silteux et argileux tandis que les cendres volantes de Battle River, classe F, utilisées seules, n'apportent qu'un gain tout à fait relatif, si gain il y a. Le rapport compare l'efficacité des produits nouveaux ci-dessus à celle du ciment et de la chaux utilisés seuls, se basant pour cela sur les résultants d'une recherche documentaire. Cette comparaison est suivie d'une étude économique de l'utilisation des divers agents de traitement considérés. Cette étude conclut que le Fujibeton B est un agent de stabilisation efficace des sols silteux et sablonneux et une bon correcteur des propriétés des sols argileux, et que son emploi est économiquement justifié lorsque les distances de transport des graviers et bitumes utilisables à sa place sont importantes. Les mélanges ciment-cendres volantes sont efficaces dans le cas des sols silteux et sablonneux mais leur emploi n'est pas rentable dans l'optique des constructions de routes secondaires envisagées ici.

18. **Mots-clés** Stabilisation des sols, modification des sols, sol-ciment, centres volantes, lignocellulose, terrassements, sensibilité au gel, instabilité volumique

19. **Diffusion**
Le Centre de développement des transports dispose d'un nombre limité d'exemplaires

20. **Classification de sécurité (de ce rapport)**
non-classifié

21. **Classification de sécurité (de cette page)**
non-classifiée

22. **Nombre de pages**

23. **Prix**
--

CDT/TDC 79-005

SUMMARY

In this volume of the report detailed laboratory test results are presented.

The test results are arranged for each of the five sites sampled as shown on the Table of Contents.

The test results are presented in two sections for each site; these are control tests and investigative tests. The investigative test results for the lignin cellulose cement stabilizer (Fujibeton B) are given before the test results for flyash in each section. The results for tests carried out using flyash and cement combined are presented after the test results for flyash.

The compressive strength test results are presented on the appropriate durability test result sheets.

TABLE OF CONTENTS

APPENDIX A - Laboratory Test Procedure

APPENDIX B - Laboratory Tests Carried out on Samples from Calgary Bearspaw Site.

- Control Tests - Moisture Density Relations, California Bearing Ratio
- Investigative Tests - Atterberg Limits, Moisture Density Relations, California Bearing Ratio, Wet-Dry Durability and Unconfined Compressive Strength, Freeze-Thaw Durability and Unconfined Compressive Strength

APPENDIX C - Laboratory Tests Carried out on Samples from Calgary Airport Site.

- Control Tests - Moisture Density Relations, California Bearing Ratio
- Investigative Tests - Atterberg Limits, Moisture Density Relations, California Bearing Ratio, Wet-Dry Durability and Unconfined Compressive Strength, Freeze-Thaw Durability and Unconfined Compressive Strength

APPENDIX D - Laboratory Tests Carried out on Samples from Pincher Creek Site.

- Control Tests - Moisture Density Relations, California Bearing Ratio

TABLE OF CONTENTS (continued)

- o Investigative Tests - Atterberg Limits, Moisture Density Relations, California Bearing Ratio, Wet-Dry Durability and Unconfined Compressive Strength, Freeze-Thaw Durability and Unconfined Compressive Strength

APPENDIX E - Laboratory Tests Carried out on Samples from Drumheller Site.

- o Control Tests - Moisture Density Relations, California Bearing Ratio
- o Investigative Tests - Atterberg Limits, Moisture Density Relations, California Bearing Ratio, Wet-Dry Durability and Unconfined Compressive Strength, Freeze-Thaw Durability and Unconfined Compressive Strength

APPENDIX F - Laboratory Tests Carried out on Samples from Bashaw Site.

- o Control Tests - Moisture Density Relations, California Bearing Ratio
- o Investigative Tests - Atterberg Limits, Moisture Density Relations, California Bearing Ratio, Wet-Dry Durability and Unconfined Compressive Strength, Freeze-Thaw Durability and Unconfined Compressive Strength

APPENDIX A
LABORATORY TEST PROCEDURES

1.0 PARTICLE SIZE ANALYSIS OF SOILS ASTM D422

Analyses by sieving and using the hydrometer method were carried out.

2.0 ATTERBERG LIMITS DETERMINATION

Liquid Limit ASTM D423

Plastic Limit ASTM D424

Determinations were carried out on natural soil and on soil stabilizer mixtures.

The soil stabilizer mixtures were made up from crushed dry soil, the appropriate dosage of stabilizer and sufficient water to bring the mixture to a uniform moisture content just above the optimum mositure content for field compaction. The soil stabilizer mixtures were then stored at 20°C for the appropriate curing period in small sealed containers to reduce evaporation losses. The Atterberg limits were then determined for the soil stabilizer mixtures in the usual way.

3. MOISTURE DRY DENSITY RELATIONSHIP OF SOIL (ASTM D698) AND SOIL STABILIZER MIXTURES (ASTM D558)

The relationship between moisture content and dry density achieved using a specified compactive effort was determined for natural soil and for soil stabilizer mixtures.

Two levels of compactive effort were utilized for this laboratory testing program, standard compactive effort and compactive effort nominally 75% of standard compactive effort.

Standard compactive effort is defined in ASTM D698 as 25 blows per lift using a 5.5 lb. rammer in the case of the 4" mould and as 56 blows per lift using a 5.5 lb. rammer in the case of the 6" mould. For this laboratory study of soil stabilizers 19 or 42 blows per lift were utilized where nominally 75% of standard compactive effort was specified for soils to be compacted in the 4" or 6" moulds, respectively.

4.0 BEARING RATIO OF COMPACTED SOILS - ASTM D1883

The California Bearing Ratios of laboratory compacted natural soils were determined for soils compacted, using standard compactive effort and using nominally 75% of standard compactive effort, at various moisture contents. Moisture contents ranged from values significantly below field optimum moisture content for compaction to significantly above field optimum moisture content. A 10 lb. surcharge was applied to each specimen during testing. Specimens were not soaked and generally were tested within about an hour of being compacted.

The California Bearing Ratios of laboratory compacted soil stabilizer mixtures were determined generally for two conditions. Specimens were either compacted at about optimum moisture content to the maximum dry density obtained during the standard compaction test or to the maximum dry density obtained during the compaction test utilizing 75% of standard energy. Specimens were then cured for seven days at 20°C and 100% humidity before being tested. A surcharge of 10 lb. was applied to each specimen during testing.

5. WET-DRY DURABILITY TESTS OF COMPACTED SOIL STABILIZER MIXTURES (ASTM D559)

Wet-dry durability tests were carried out by one of two methods of sample preparation. The first method of sample preparation generally comprised static compaction using a hydraulic ram, of a specimen at optimum moisture content to approximately 95% of the maximum dry density obtained utilizing standard compactive effort. The second method of sample preparation comprised dynamic compaction using 19 blows of a 5.5 lb. rammer for each lift of soil which is equivalent to sample compaction using nominally 75% of standard compactive effort. One specimen was made for each durability test.

Records were taken of specimen size and weight after soaking and after drying and brushing for each cycle during which the test specimen remained intact. From this data volume and moisture changes and soil cement losses of the test specimen were obtained.

The corrected dry weight of the specimen at the end of the durability test, allowing for water which was combined with the stabilizing agent, was calculated by assuming that the weight of chemically bonded water was equal to 25% of the total weight of stabilizing agent.

6.0 FREEZE-THAW DURABILITY TESTS OF COMPACTED SOIL STABILIZER MIXTURES - (ASTM D560)

Freeze-thaw durability tests were carried out adopting two methods of sample preparation. The first method comprised static compaction, using a hydraulic ram, of a specimen at optimum moisture content to approximately 95% of the maximum dry density obtained utilizing standard compactive effort. The second method of sample preparation comprised dynamic compaction using 19 blows of a 5.5 lb. rammer for each lift of soil which corresponds to sample compaction utilizing nominally 75% of standard compactive effort. One specimen was made for each durability test.

Records were taken of specimen size and weight after thawing and brushing for each cycle during which the test specimen remained intact. It was intended to measure specimen size and weight after freezing. However, this was impossible as specimens generally would adfreeze to the absorbant foam used to provide water to the sample. From this data, volume and moisture content changes and soil cement losses of the test specimen were obtained.

The corrected dry weight of the specimen at the end of the durability test allowing for water which has combined with the stabilizing agent was calculated by assuming that the weight of chemically bonded water was equal to 25% of the total weight of stabilizing agent.

7.0 UNCONFINED COMPRESSION TEST ON COMPACTED SOIL STABILIZER MIXTURES AFTER DURABILITY TESTING

Following completion of durability testing the oven dried specimens remaining intact were subjected to an unconfined compression test.

In view of the small length to diameter ratio and the pitted and mishapen appearance of the specimens after completion of the durability tests a basic testing procedure as described below was adopted.

The dimensions of the test specimens were recorded. The specimen was placed and centred in the compression test apparatus then loaded. A loading rate was selected so that the specimen would fail within less than about 5 minutes. This loading rate corresponds to a strain rate of less than 1% per minute for the specimens tests. The unconfined compressive strength of the sample was calculated by dividing the maximum load on the specimen during the test by the measured cross sectional area of the specimen then correcting that value for the small length to diameter ratio of the specimen. The correction used was taken from CSA A23.2-14C and is given below.

LENGTH: DIAMETER RATIO	CORRECTION FACTOR
2.00	1.00
1.75	0.98
1.50	0.96
1.25	0.93
1.00	0.87

The unconfined compressive strengh as recorded in this report is the measured strength multiplied by the appropriate correction factor interpolated from the data given above.

APPENDIX B

LABORATORY TEST RESULTS
CALGARY BEARSPAW

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1SD83 - 00026

Project No.: 314 - 1264.02

Stabilizer Dosage: FUJIBETON 0 %

Sample: Calgary: Bearspaw

FLYASH 0 %

Sand 24% , Silt 51% , Clay 25%

CEMENT 0 %

TEST DATA:

1) Method of Sample Preparation: ASTM D 558 - 57

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m^3)
1	11.0	1622
2	11.4	1631
3	18.0	1765
4	19.7	1702
5	20.7	1648

Design Field Optimum Moisture Content: 16.0 %

Design Field Maximum Dry Density: 1780 kg/m^3

2) Method of Sample Preparation: ASTM D558 - 57, but using 19 blows to compact each layer instead of 25 blows

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m^3)
1	10.9	1590
2	11.0	1625
3	18.1	1694
4	18.6	1706
5	18.9	1707

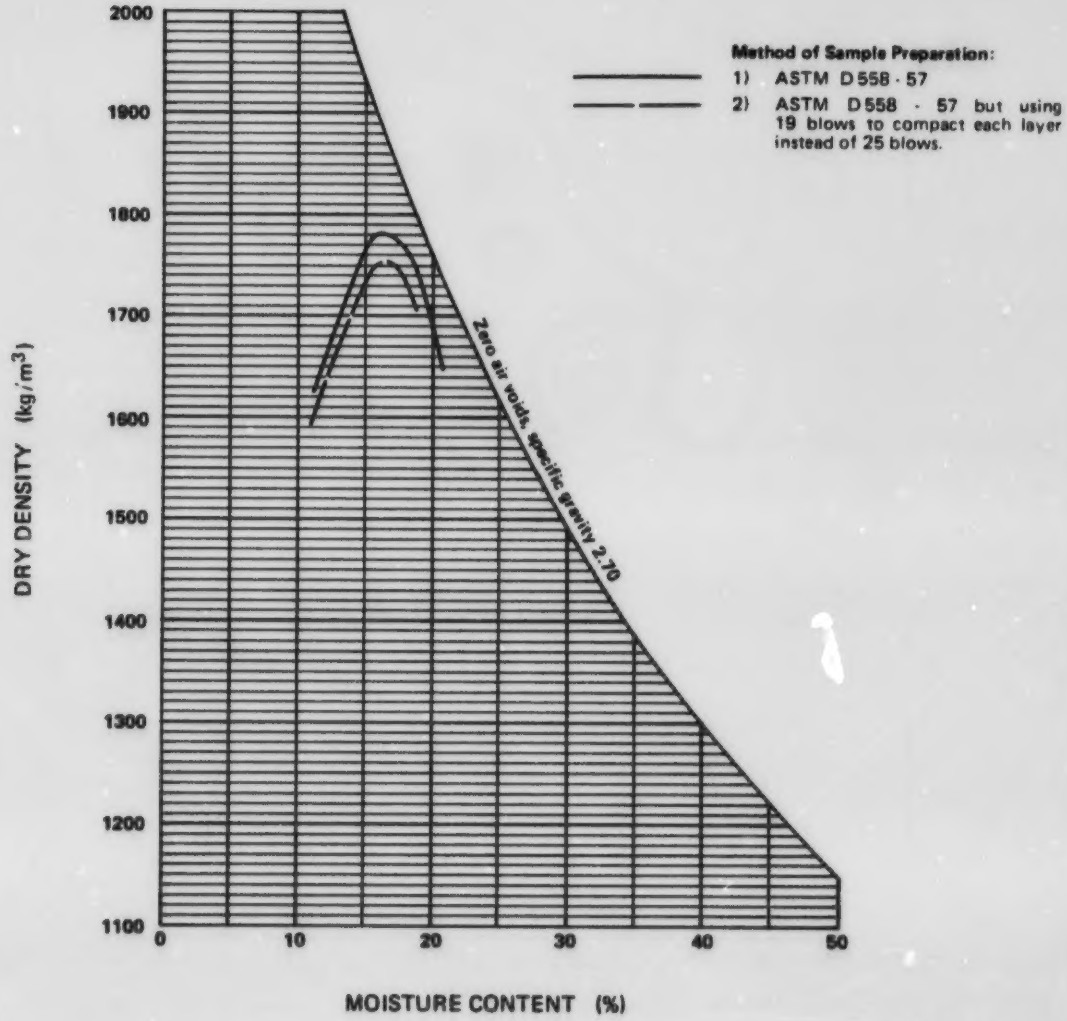
Design Field Optimum Moisture Content: 16.0 %

Design Field Maximum Dry Density: 1750 kg/m^3

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA	Contract No.: 1 SD 83 - 00026		
Project No.: 314 - 1264.02	Stabilizer Dosage:	FUJIBETON	0 %
Sample: Bearspaw		FLYASH	0 %
Sand 24%, Silt 51%, Clay 25%		CEMENT	0 %



SHEET 2 OF 2

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1SD83 - 00026

Project No.: 314 - 1264.02

Sample: Calgary: Bearspaw

Sand 24%, Silt 51%, Clay 25%

Stabilizer Dosage: FUJIBETON 0 %

FLYASH 0 %

CEMENT 0 %

TEST DATA:

1) Method of Sample Preparation: ASTM D 558 - 57

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	10.9	1650
2	12.6	1707
3	13.7	1743
4	16.5	1757
5	18.7	1706

Design Field Optimum Moisture Content: 16.0 %

Design Field Maximum Dry Density: 1780 kg/m³

2) Method of Sample Preparation: ASTM D558 - 57, but using 19 blows to compact each layer instead of 25 blows

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	10.7	1569
2	11.6	1638
3	17.0	1735
4	19.7	1697
5	19.7	1674

Design Field Optimum Moisture Content: 16.0 %

Design Field Maximum Dry Density: 1750 kg/m³

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

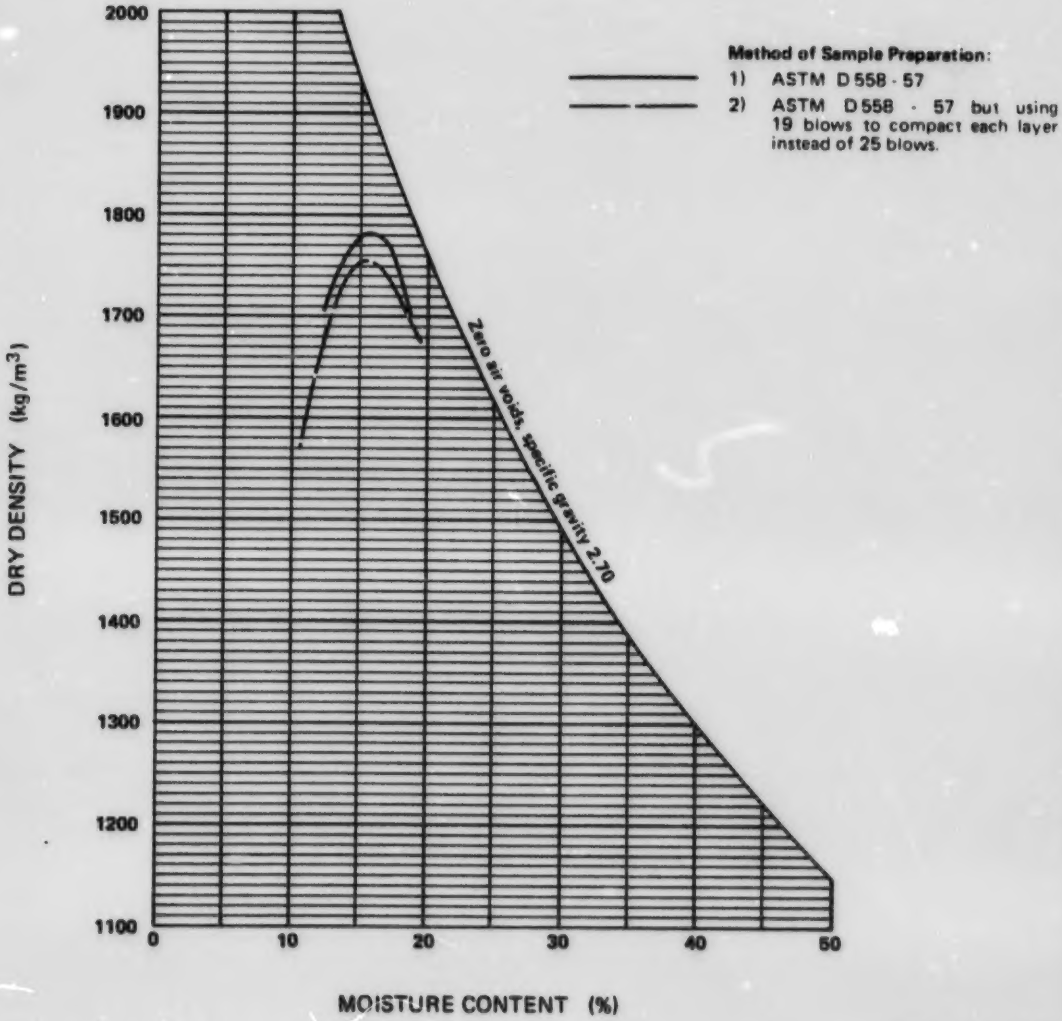
Stabilizer Dosage: FUJIBETON 0 %

Sample: Bearspaw

FLYASH 0 %

Sand 24% , Silt 51% , Clay 25%

CEMENT 0 %



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02 Stabilizer Dosage: None

Sample: Calgary: Bearspaw

Sand 24%, Silt 51%, Clay 25%

Samples compacted using 100% of standard energy

TEST	DRY DENSITY (kg/m³)	MOISTURE CONTENT (%)	CALIFORNIA BEARING RATIO (%)	
			2.5 mm Penetration	5.0 mm Penetration
1	1622	11.0	21	18
2	1648	20.7	1.2	1.0
3	1631	11.4	17	14
4	1765	18.0	3.7	4.2
5	1702	19.7	1.7	2.0
6	1650	10.9	20	19
7	1707	12.6	17	16
8	1743	13.7	11	9.6
9	1757	16.5	6.3	6.2
10	1706	18.7	1.7	1.9

CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA Contract No.: 1 SD 83-00026

Project No.: 314-1264.02 Stabilizer Dosage: None

Sample: Calgary: Bearspaw

Sand 24%, Silt 51%, Clay 25%

Samples compacted using 75 % of standard energy

TEST	DRY DENSITY (kg/m^3)	MOISTURE CONTENT (%)	CALIFORNIA BEARING RATIO (%)	
			2.5 mm Penetration	5.0 mm Penetration
1	1638	11.6	20	18
2	1694	18.1	2.3	3.0
3	1735	17.0	5.7	6.4
4	1697	19.7	1.8	1.9
5	1590	10.9	18	18
6	1569	10.7	16	17
7	1625	11.0	21	20
8	1707	18.9	1.0	1.7
9	1674	19.7	1.0	1.7
10	1706	18.6	1.0	1.8

EBA Engineering Consultants Ltd.

ATTERBERG LIMITS TEST DATA

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264. 02

SAMPLE	STABILIZER DOSAGE (%)			REACTION TIME (hours)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX
	FUJIBETON	FLYASH	CEMENT				
Calgary: Bearspaw	0	0	0	–	20.4	26.8	6.4
	0	0	0	–	18.6	25.8	7.2
	2	–	–	0.25 (mix.)	24.0	34.0	10.0
	2	–	–	1	26.5	36.1	9.5
	2	–	–	24	–	–	Non Plastic
	4	–	–	0.25 (mix.)	25.6	35.0	9.4
	4	–	–	1	–	–	Non Plastic
	4	–	–	24	–	–	Non Plastic
	7	–	–	0.25 (mix.)	24.7	31.8	7.1
	7	–	–	1	–	–	Non Plastic
	7	–	–	24	–	–	Non Plastic
	9	–	–	0.25 (mix.)	–	–	Non Plastic
	9	–	–	1	–	–	Non Plastic
	9	–	–	24	–	–	Non Plastic
	12	–	–	0.25 (mix.)	–	–	Non Plastic
	12	–	–	1	–	–	Non Plastic
	12	–	–	24	–	–	Non Plastic
	–	2	–	0.25 (mix.)	18.8	25.8	7.0
	–	2	–	1	17.8	23.7	5.9
	–	2	–	24	17.3	23.2	5.9
	–	6	–	0.25 (mix.)	20.2	28.4	8.2
	–	6	–	1	17.6	23.4	5.8
	–	6	–	24	16.6	23.9	7.3
	–	10	–	0.25 (mix.)	19.0	25.8	6.8
	–	10	–	1	17.5	22.5	5.0
	–	10	–	24	17.3	23.5	6.2
	–	13	–	0.25 (mix.)	18.7	26.2	7.5

ATTERBERG LIMITS TEST DATA

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264. 02

SAMPLE	STABILIZER DOSAGE (%)			REACTION TIME (hours)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX
	FUJIBETON	FLYASH	CEMENT				
Calgary: Bearspaw	–	13	–	1	16.9	23.1	6.2
	–	13	–	24	17.7	22.5	4.8
	–	16	–	0.25 (mix.)	18.2	25.6	7.4

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1SD83 - 00026

Project No.: 314 - 1264.02

Stabilizer Dosage: FUJIBETON 2 %

FLYASH %

CEMENT %

Sample: Calgary: Bearspaw

Sand 24%, Silt 51%, Clay 25%

TEST DATA:

1) Method of Sample Preparation: ASTM D 558 - 57

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	13.8	1694
2	16.8	1734
3	20.1	1658
4	22.9	1575
5	10.8	1612

Design Field Optimum Moisture Content: 16.5 %

Design Field Maximum Dry Density: 1735 kg/m³

2) Method of Sample Preparation: ASTM D558 - 57, but using 19 blows to compact each layer instead of 25 blows

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	16.2	1683
2	16.3	1664
3	14.2	1805
4	20.1	1648
5		

Design Field Optimum Moisture Content: 16.2 %

Design Field Maximum Dry Density: 1683 kg/m³

SHEET 1 OF 2

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

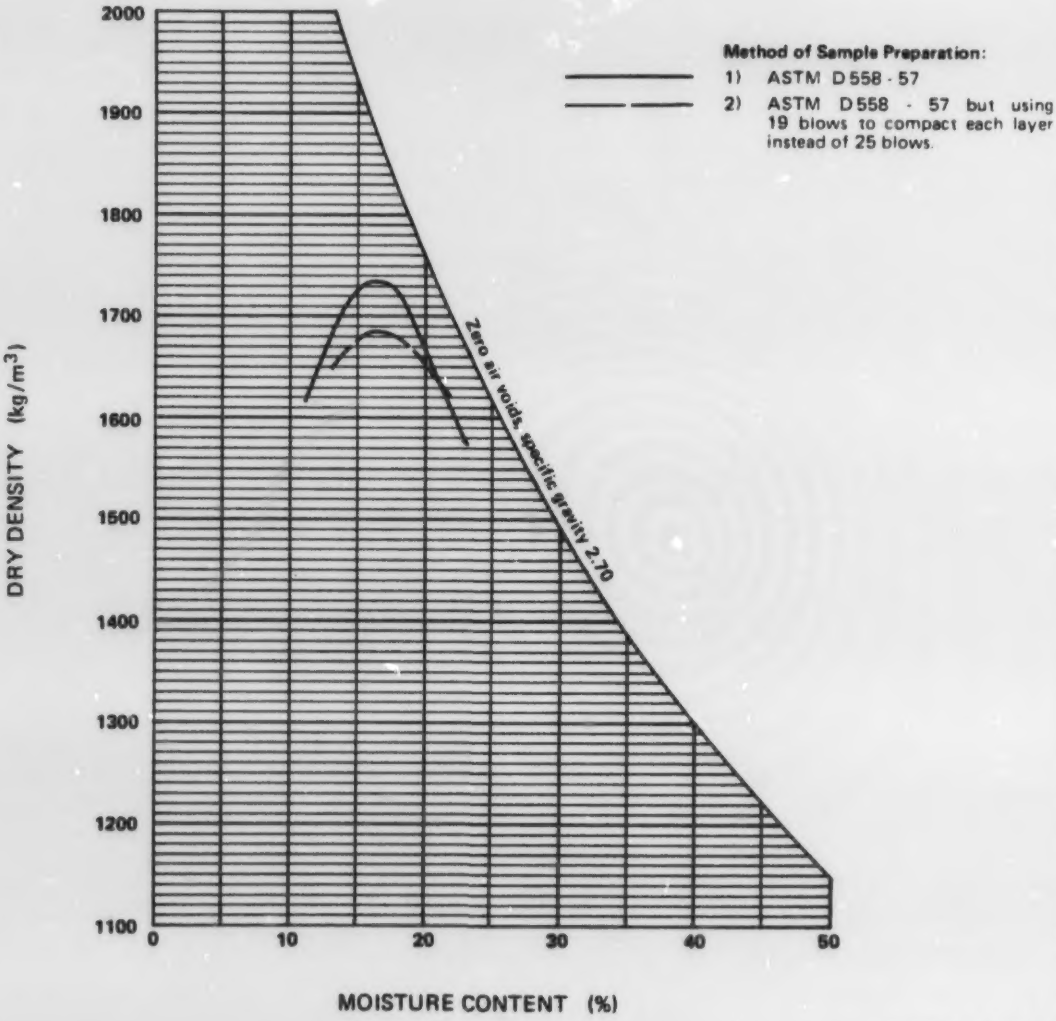
Stabilizer Dosage: FUJIBETON 2 %

FLYASH %

CEMENT %

Sample: Calgary: Bearspaw

Sand 24 % . Silt 51 % , Clay 25 %



SHEET 2 OF 2

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1SD83 - 00026

Project No.: 314 - 1264.02

Stabilizer Dosage: FUJIBETON 4 %

FLYASH %

CEMENT %

Sample: Calgary: Bearspaw

Sand 24%, Silt 51%, Clay 25%

TEST DATA:

1) Method of Sample Preparation: ASTM D 558 - 57

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	13.4	1670
2	16.0	1717
3	19.4	1672
4	22.9	1580
5	26.0	1495

Design Field Optimum Moisture Content: 16.5 %

Design Field Maximum Dry Density: 1720 kg/m³

2) Method of Sample Preparation: ASTM D558 - 57, but using 19 blows to compact each layer instead of 25 blows

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	16.3	1674
2	16.6	1669
3	14.2	1662
4	19.7	1657
5		

Design Field Optimum Moisture Content: 1674 %

Design Field Maximum Dry Density: 16.3 kg/m³

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

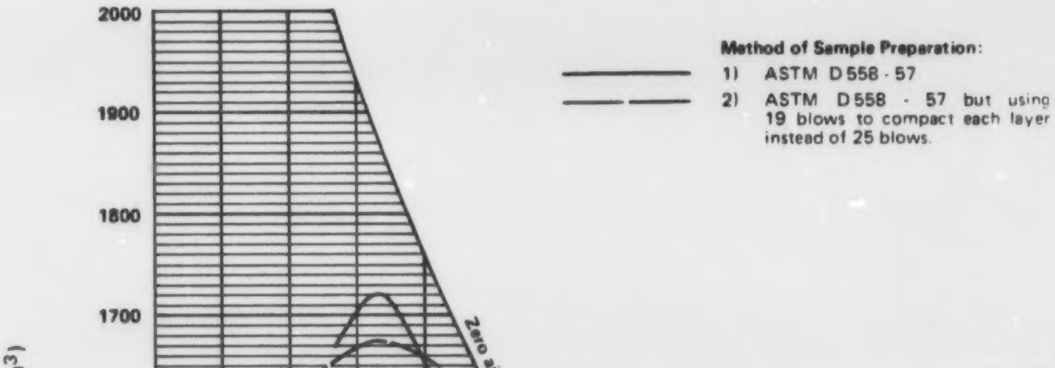
Stabilizer Dosage: FUJIBETON 4 %

FLYASH %

CEMENT %

Sample: Calgary: Bearspaw

Sand 24 %, Silt 51 %, Clay 25 %



SHEET 2 OF 2

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1SD83 - 00026

Project No.: 314 - 1264.02

Stabilizer Dosage: FUJIBETON 7 %

FLYASH %

CEMENT %

Sample: Calgary: Bearspaw

Sand 24%, Silt 51%, Clay 25%

TEST DATA:

1) Method of Sample Preparation: ASTM D 558 - 57

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	12.7	1665
2	16.2	1711
3	19.3	1680
4	22.1	1611
5	24.7	1526

Design Field Optimum Moisture Content: 16.5 %

Design Field Maximum Dry Density: 1720 kg/m³

2) Method of Sample Preparation: ASTM D558 - 57, but using 19 blows to compact each layer instead of 25 blows

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	16.2	1667
2	16.2	1675
3	14.1	1673
4	20.3	1662
5		

Design Field Optimum Moisture Content: 16.2 %

Design Field Maximum Dry Density: 1675 kg/m³

SHEET 1 OF 2

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

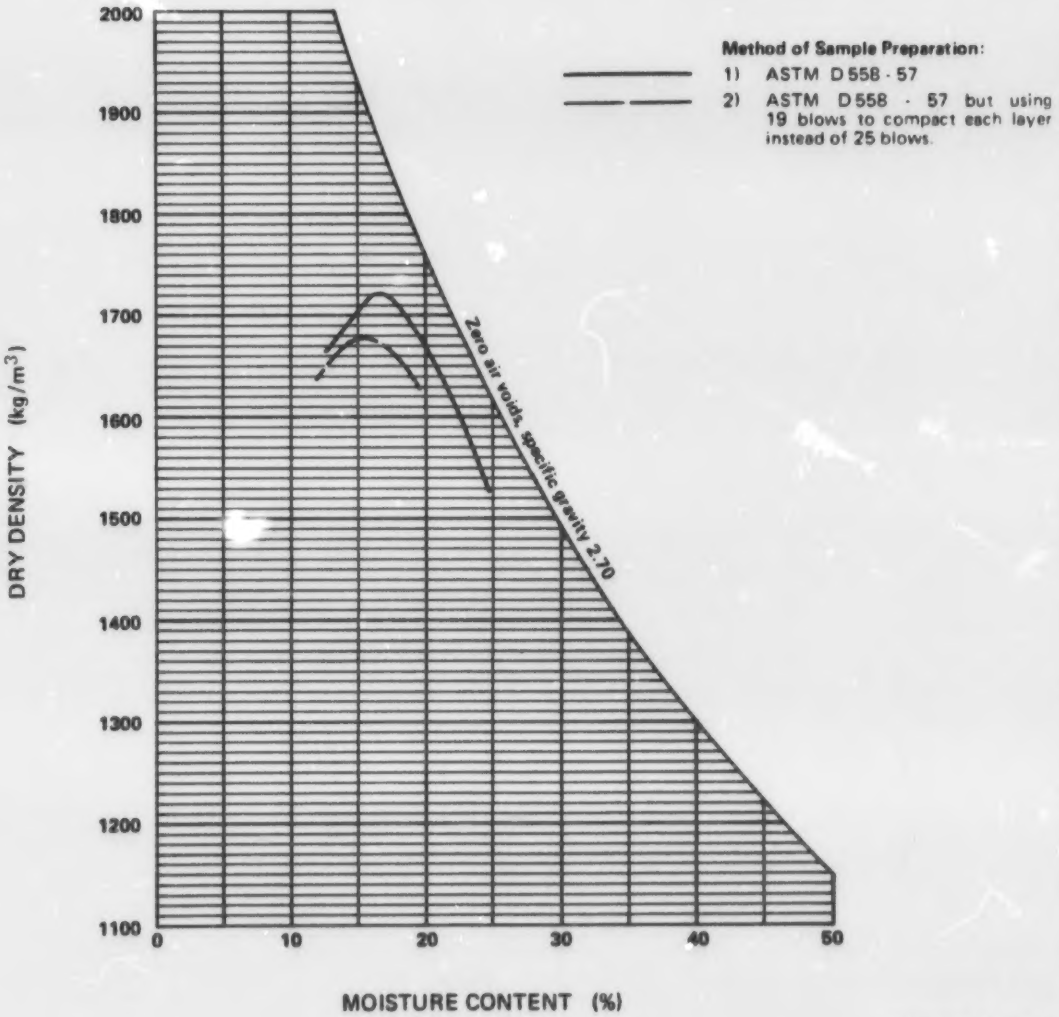
Stabilizer Dosage: FUJIBETON 7 %

FLYASH %

CEMENT %

Sample: Calgary: Bearspaw

Sand 24 %, Silt 51 %, Clay 25 %



SHEET 2 OF 2

EBA Engineering Consultants Ltd.

eba

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA Contract No.: 1SD83 - 00026

Project No.: 314 - 1264.02 Stabilizer Dosage: FUJIBETON 9 %

Sample: Calgary: Bearspaw FLYASH %

Sand 24%, Silt 51%, Clay 25% CEMENT %

TEST DATA:

1) Method of Sample Preparation: ASTM D 558 - 57

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m^3)
1	12.4	1662
2	15.7	1698
3	18.7	1690
4	20.8	1639
5	24.6	1544

Design Field Optimum Moisture Content: 16.5 %

Design Field Maximum Dry Density: 1715 kg/m^3

2) Method of Sample Preparation: ASTM D558 - 57, but using 19 blows to compact each layer instead of 25 blows

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m^3)
1	15.8	1667
2	16.6	1687
3	14.4	1688
4	17.7	1716
5		

Design Field Optimum Moisture Content: 17.7 %

Design Field Maximum Dry Density: 1716 kg/m^3

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

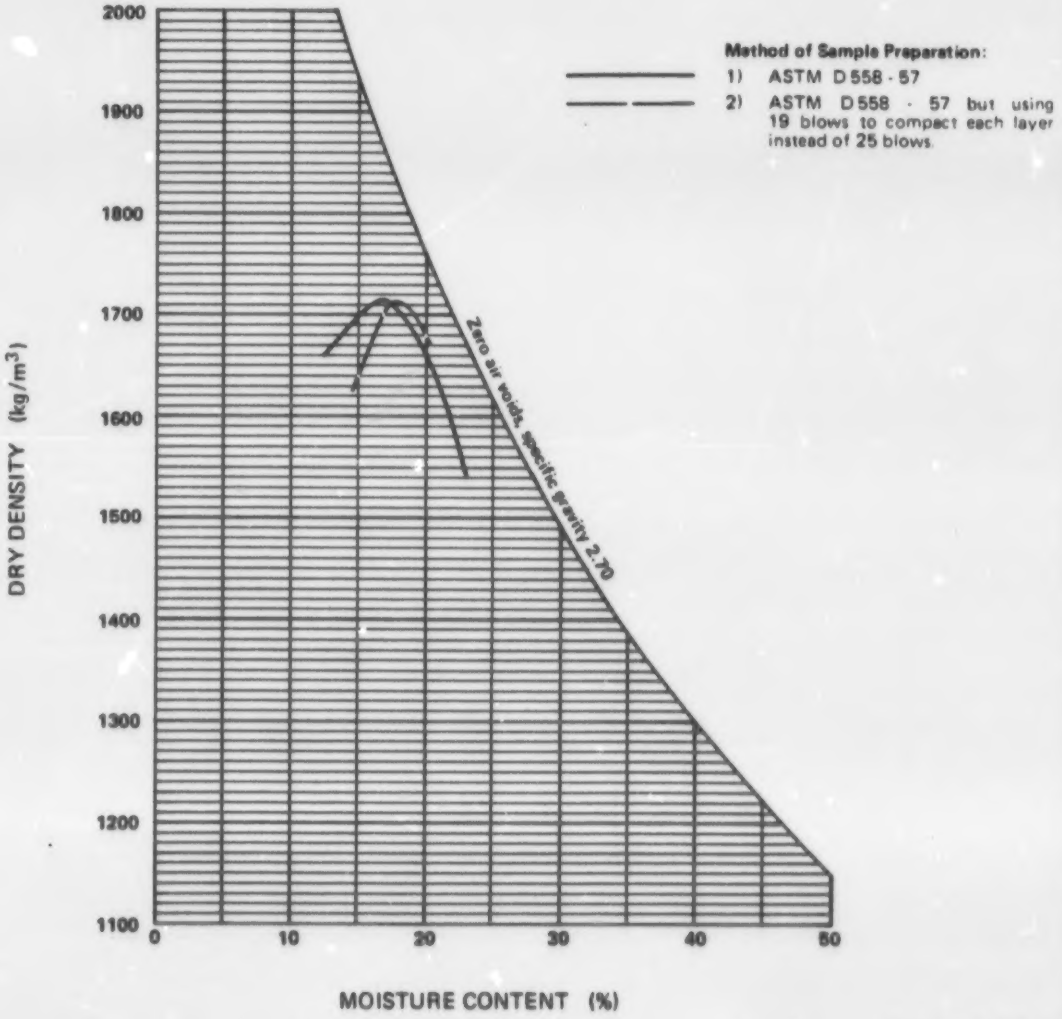
Stabilizer Dosage: FUJIBETON 9 %

FLYASH %

CEMENT %

Sample: Calgary: Bearspaw

Sand 24 %, Silt 51 %, Clay 25 %



SHEET 2 OF 2

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1SD83 - 00026

Project No.: 314 - 1264.02

Stabilizer Dosage: FUJIBETON 12 %

FLYASH %

CEMENT %

Sample: Calgary: Bearspaw

Sand 24%, Silt 51%, Clay 25%

TEST DATA:

1) Method of Sample Preparation: ASTM D 558 - 57

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	12.4	1675
2	15.4	1710
3	18.3	1698
4	21.5	1607
5	24.2	1553

Design Field Optimum Moisture Content: 16.0 %

Design Field Maximum Dry Density: 1720 kg/m³

2) Method of Sample Preparation: ASTM D558 - 57, but using 19 blows to compact each layer instead of 25 blows

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	16.2	1686
2	16.7	1675
3	14.3	1688
4	19.2	1678
5		

Design Field Optimum Moisture Content: 16.5 %

Design Field Maximum Dry Density: 1690 kg/m³

SHEET 1 OF 2

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

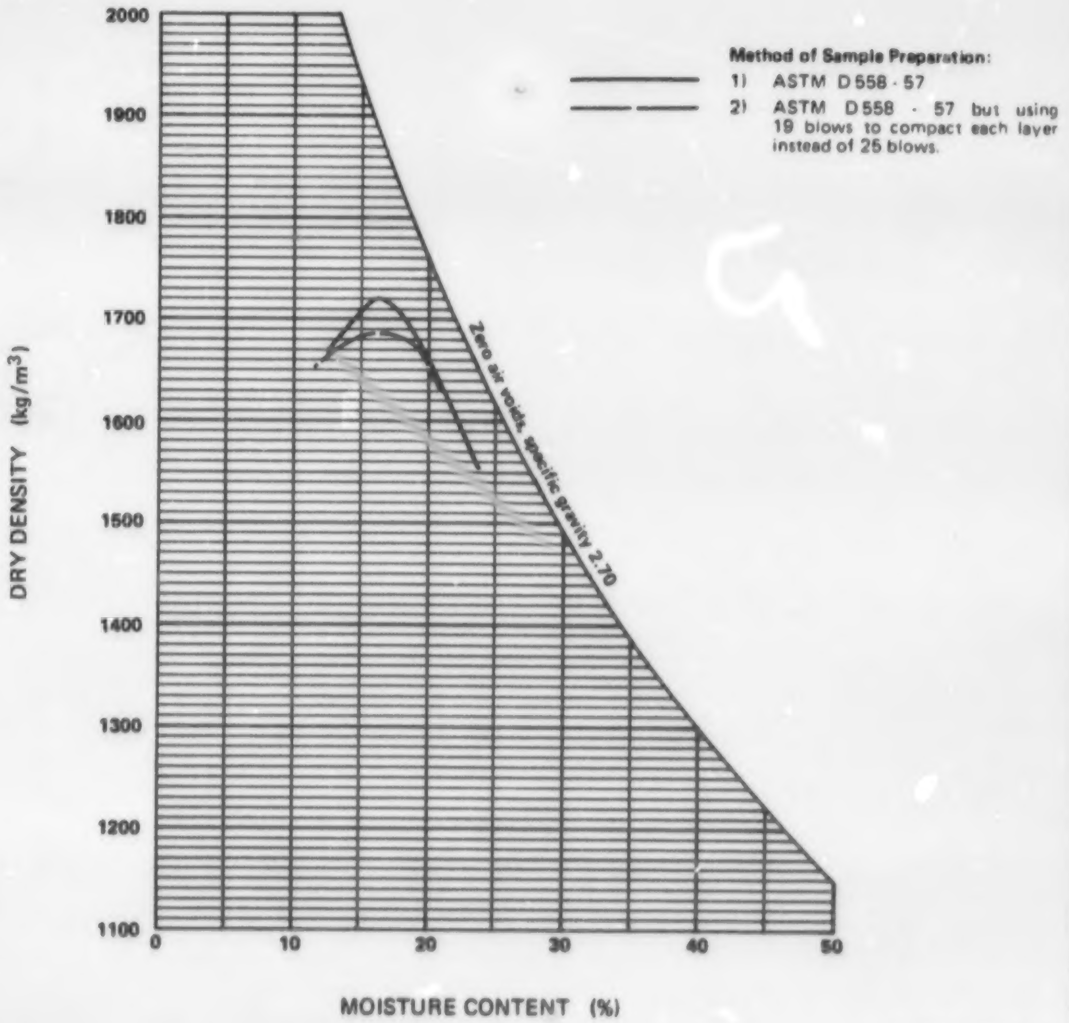
Stabilizer Dosage: FUJIBETON 12 %

Sample: Calgary: Bearspaw

FLYASH %

Sand 24 %, Silt 51 %, Clay 25 %

CEMENT %



DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1SD83 - 00026

Project No.: 314 - 1264.02

Stabilizer Dosage: FUJIBETON ______ %

FLYASH 2 %

CEMENT ______ %

Sample: Calgary: Bearspaw

Sand 24%, Silt 51%, Clay 25%

TEST DATA:

1) Method of Sample Preparation: ASTM D 558 - 57

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m^3)
1	15.3	1708
2	18.3	1695
3	21.4	1614
4	26.1	1507
5	12.2	1628

Design Field Optimum Moisture Content: 16.7 %

Design Field Maximum Dry Density: 1722 kg/m^3

2) Method of Sample Preparation: ASTM D558 - 57, but using 19 blows to compact each layer instead of 25 blows

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m^3)
1	16.3	1634
2	17.1	1694
3	15.7	1710
4	21.3	1602
5		

Design Field Optimum Moisture Content: 15.7 %

Design Field Maximum Dry Density: 1710 kg/m^3

SHEET 1 OF 2

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

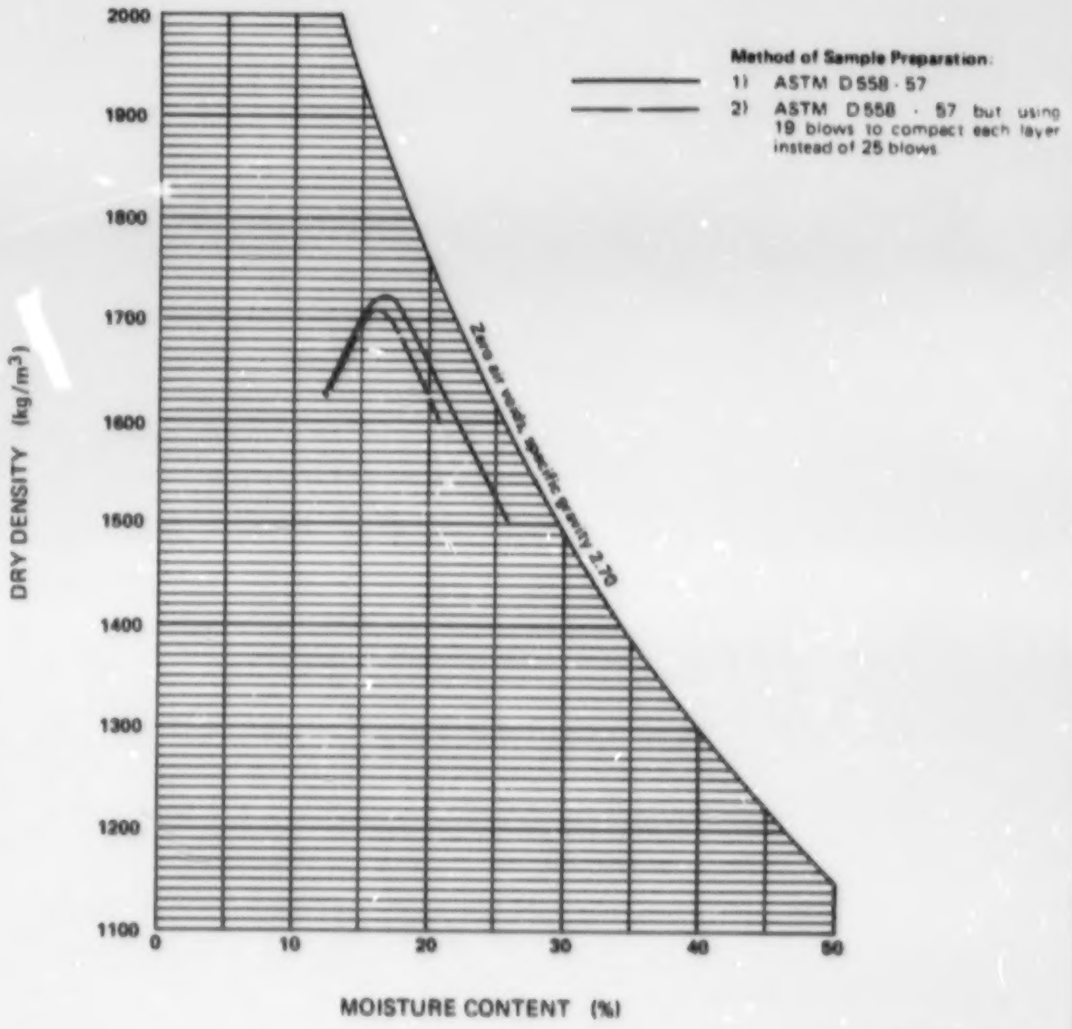
Stabilizer Dosage: FUJIBETON ____ %

Sample: Calgary: Bearspaw

FLYASH 2 %

Sand 24 %, Silt 51 %, Clay 25 %

CEMENT ____ %



DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA
Contract No.: 1SD83 - 00026

Project No.: 314 - 1264.02
Stabilizer Dosage: FUJIBETON ______ %

Sample: Calgary: Bearspaw
FLYASH 6 %

Sand 24%, Silt 51%, Clay 25%
CEMENT ______ %

TEST DATA:

1) Method of Sample Preparation: ASTM D 558 - 57

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	14.4	1725
2	17.6	1707
3	20.7	1617
4	21.7	1590
5	11.5	1648

Design Field Optimum Moisture Content: 15.0 %

Design Field Maximum Dry Density: 1725 kg/m³

2) Method of Sample Preparation: ASTM D558 - 57, but using 19 blows to compact each layer instead of 25 blows

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	16.2	1683
2	15.9	1670
3	16.0	1699
4	21.4	1599
5		

Design Field Optimum Moisture Content: 16.0 %

Design Field Maximum Dry Density: 1697 kg/m³

SHEET 1 OF 2

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

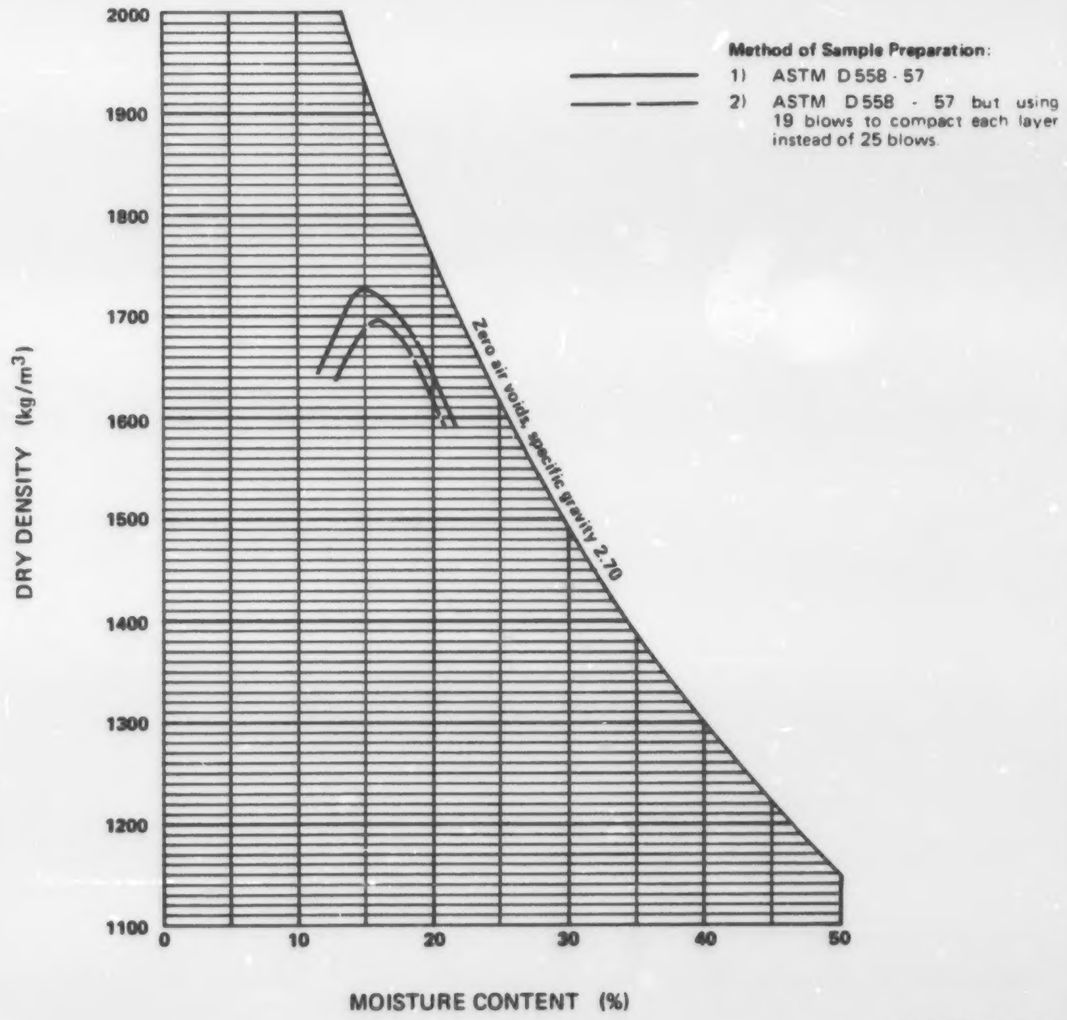
Stabilizer Dosage: FUJIBETON ______ %

Sample: Calgary: Bearspaw

FLYASH 6 %

Sand 24 %, Silt 51 %, Clay 25 %

CEMENT ______ %



DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1SD83 - 00026

Project No.: 314 - 1264.02

Stabilizer Dosage: FUJIBETON ____ %

Sample: Calgary: Bearspaw

FLYASH 10 %

Sand 24%, Silt 51%, Clay 25%

CEMENT ____ %

TEST DATA:

1) Method of Sample Preparation: ASTM D 558 - 57

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	14.1	1724
2	17.0	1722
3	20.4	1617
4	21.3	1580
5	11.1	1638

Design Field Optimum Moisture Content: 15.6 %

Design Field Maximum Dry Density: 1752 kg/m³

2) Method of Sample Preparation: ASTM D558 - 57, but using 19 blows to compact each layer instead of 25 blows

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	15.0	1719
2	17.2	1661
3	15.8	1669
4	22.1	1578
5		

Design Field Optimum Moisture Content: 15.0 %

Design Field Maximum Dry Density: 1720 kg/m³

SHEET 1 OF 2

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

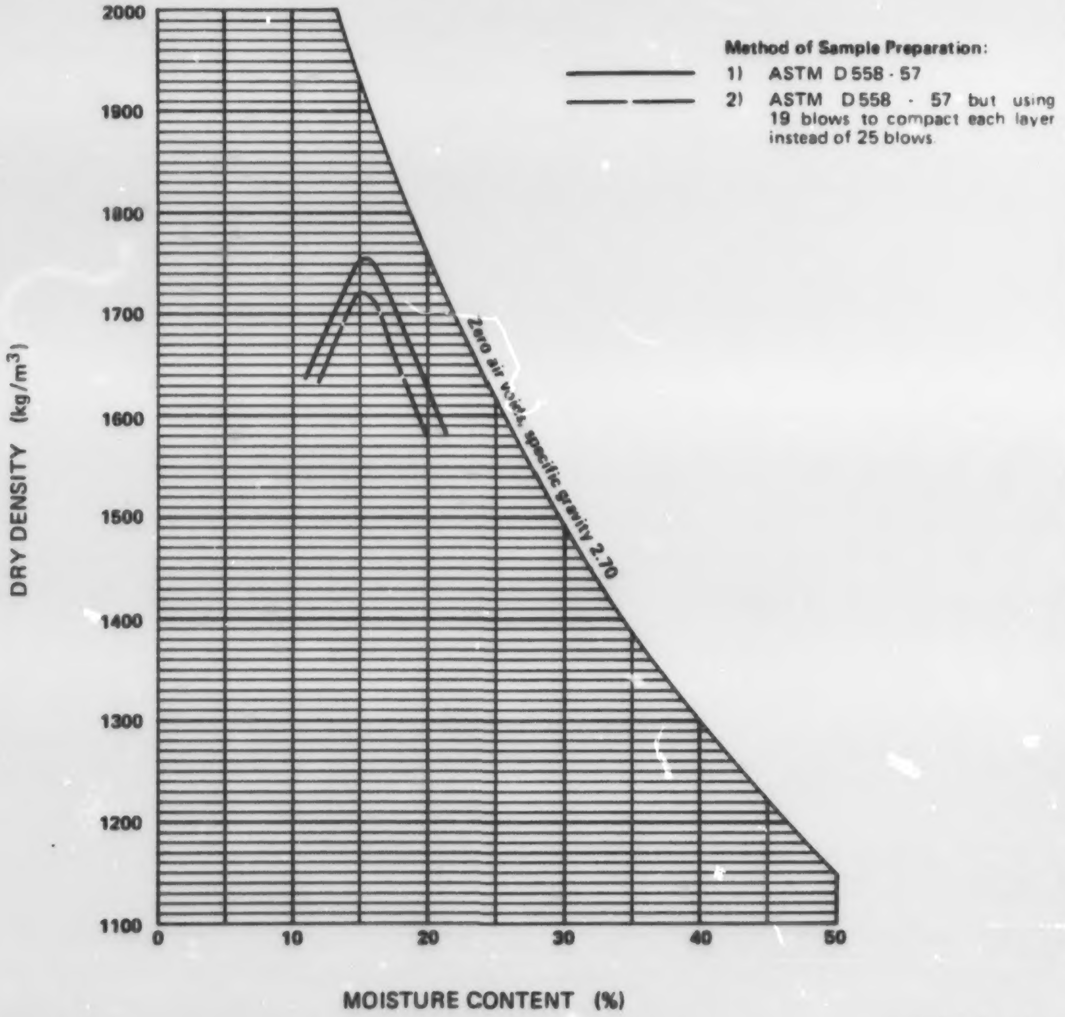
Stabilizer Dosage: FUJIBETON ______ %

Sample: Calgary: Bearspaw

FLYASH 10 %

Sand 24 %, Silt 51 %, Clay 25 %

CEMENT ______ %



SHEET 2 OF 2

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1SD83 - 00026

Project No.: 314 - 1264.02

Stabilizer Dosage: FUJIBETON ______ %

FLYASH 13 %

CEMENT ______ %

Sample: Calgary: Bearspaw

Sand 24%, Silt 51%, Clay 25%

TEST DATA:

1) Method of Sample Preparation: ASTM D 558 - 57

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	13.8	1709
2	16.7	1719
3	19.8	1623
4	21.2	1582
5	10.6	1647

Design Field Optimum Moisture Content: 15.5 %

Design Field Maximum Dry Density: 1728 kg/m³

2) Method of Sample Preparation: ASTM D558 - 57, but using 19 blows to compact each layer instead of 25 blows

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	15.2	1695
2	15.4	1708
3	14.9	1733
4	21.3	1569
5		

Design Field Optimum Moisture Content: 15.0 %

Design Field Maximum Dry Density: 1735 kg/m³

SHEET 1 OF 2

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

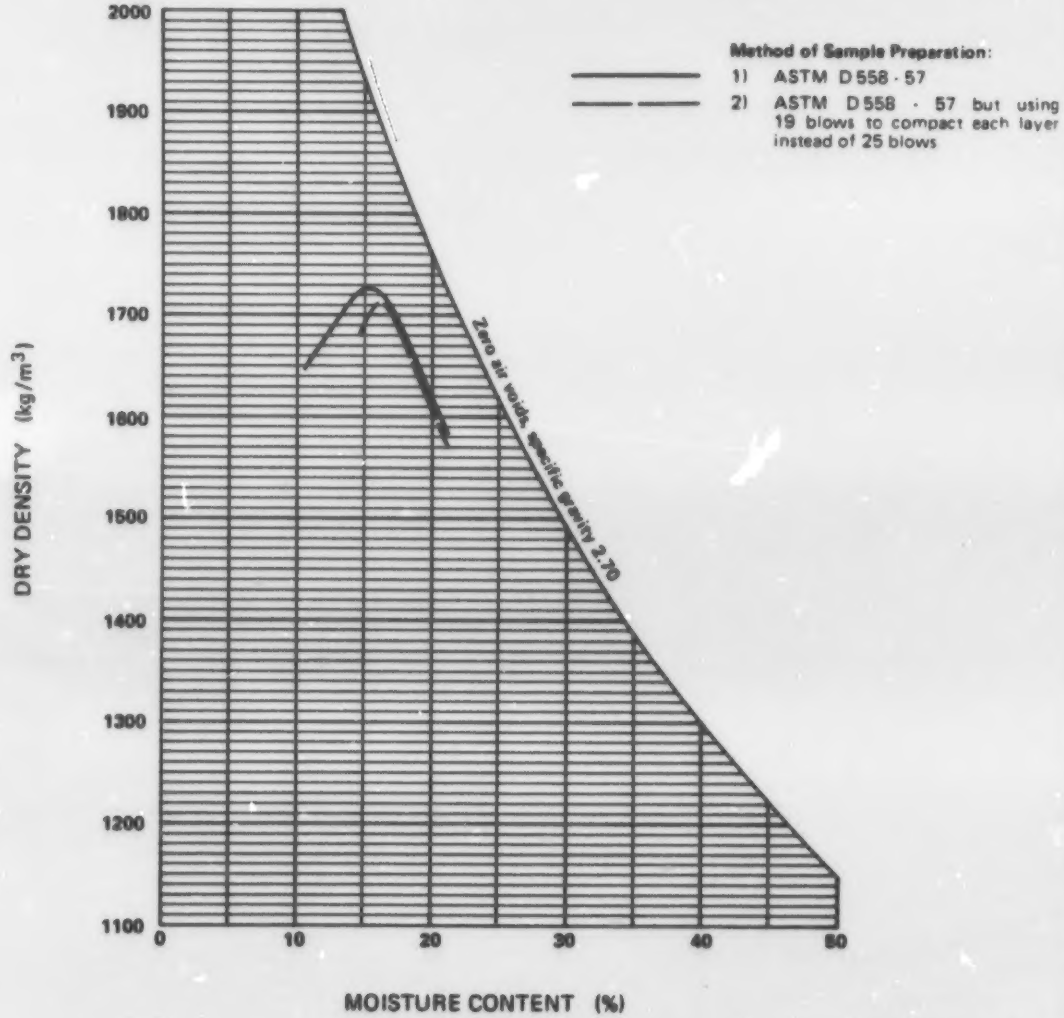
Stabilizer Dosage: FUJIBETON ____ %

FLYASH 13 %

CEMENT ____ %

Sample: Calgary: Bearspaw

Sand 24 %, Silt 51 %, Clay 25 %



SHEET 2 OF 2

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1SD83 - 00026

Project No.: 314 - 1264.02

Stabilizer Dosage: FUJIBETON %

Sample: Calgary: Bearspaw

FLYASH 7 %

Sand 24%, Silt 51%, Clay 25%

CEMENT 3 %

TEST DATA:

1) Method of Sample Preparation: ASTM D 558 - 57

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	10.7	1671
2	13.8	1699
3	17.2	1717
4	20.2	1614
5	21.6	1588

Design Field Optimum Moisture Content: 15.8 %

Design Field Maximum Dry Density: 1725 kg/m³

2) Method of Sample Preparation: ASTM D558 - 57, but using 19 blows to compact each layer instead of 25 blows

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	16.4	1658
2	16.2	1663
3	15.0	1652
4	20.9	1626
5		

Design Field Optimum Moisture Content: 16.4 %

Design Field Maximum Dry Density: 1658 kg/m³

SHEET 1 OF 2

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

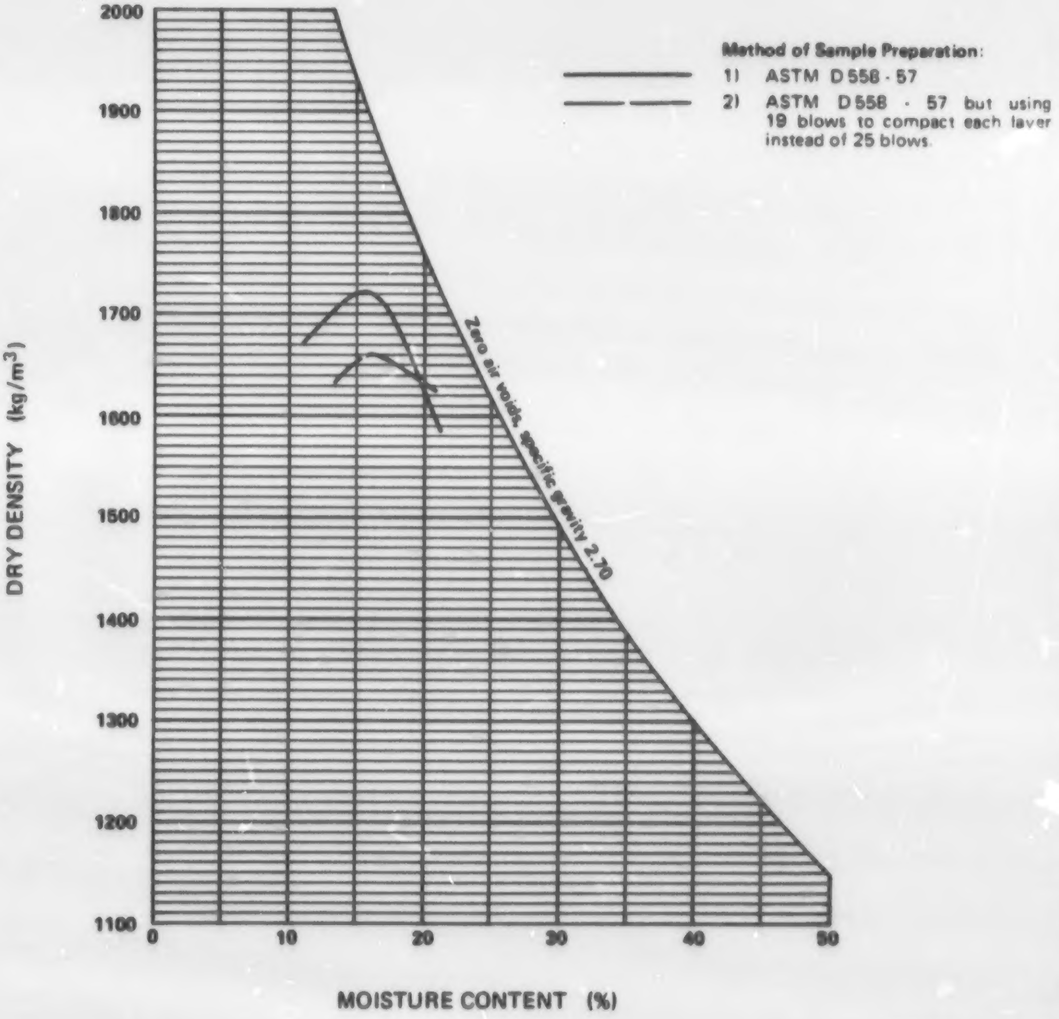
Stabilizer Dosage: FUJIBETON ____ %

Sample: Calgary: Bearspaw

FLYASH 7 %

Sand 24 %, Silt 51 %, Clay 25 %

CEMENT 3 %



SHEET 2 OF 2

CALIFORNIA BEARING RATIO TEST

Project: Laboratory Fvaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Calgary: Bearspaw

Sand 24 %, Silt 51 %, Clay 25 %

Initial Dry Density: 1406 kg/m^3

Initial Moisture Content: 23.2 %

Stabilizer Dosage: FUJIBETON 2 %

FLYASH %

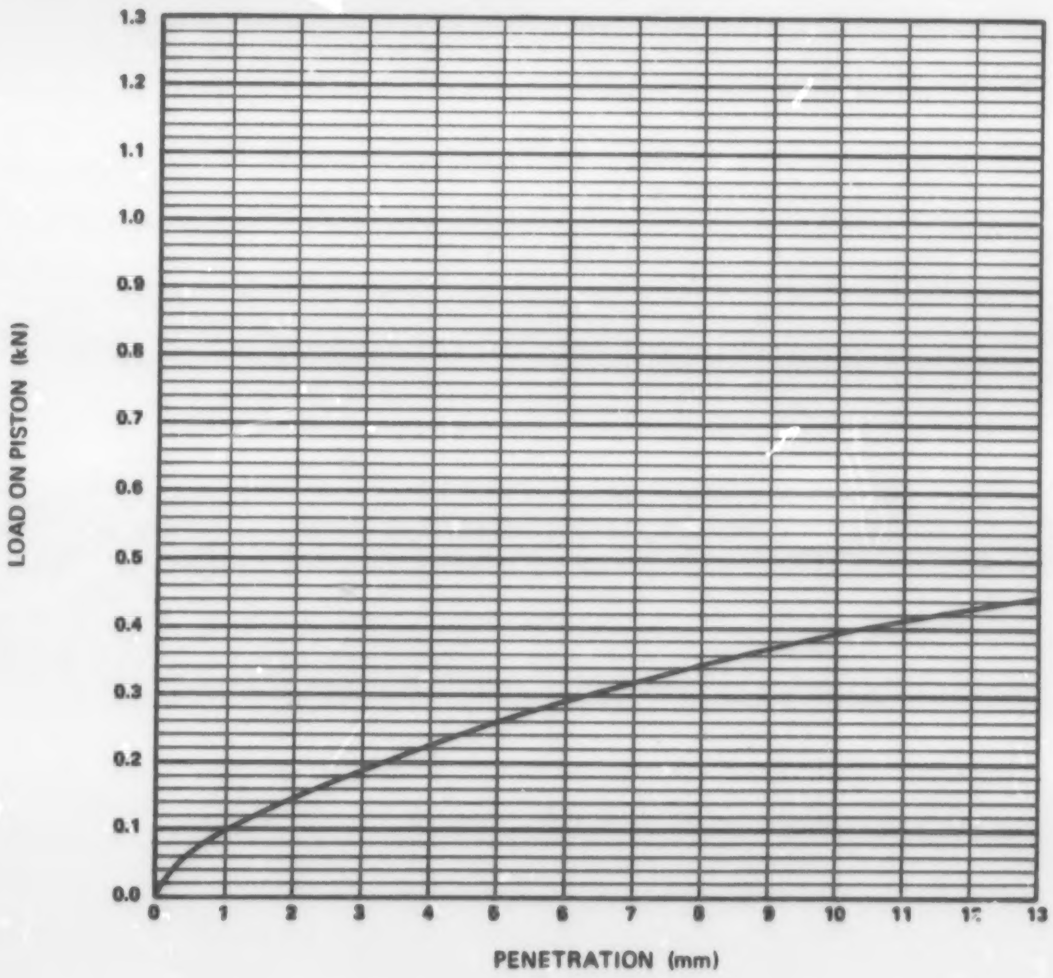
CEMENT %

Final Moisture Content: 21.8 %

California Bearing Ratio: 2.5 mm 1.3 %

5.0 mm 1.3 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 100% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Calgary: Bearspaw

Sand 24% , Silt 51% , Clay 25%

Initial Dry Density: 1684 kg/m^3

Initial Moisture Content: 15.6 %

Stabilizer Dosage: FUJIBETON 2 %

Final Moisture Content: 20.5 %

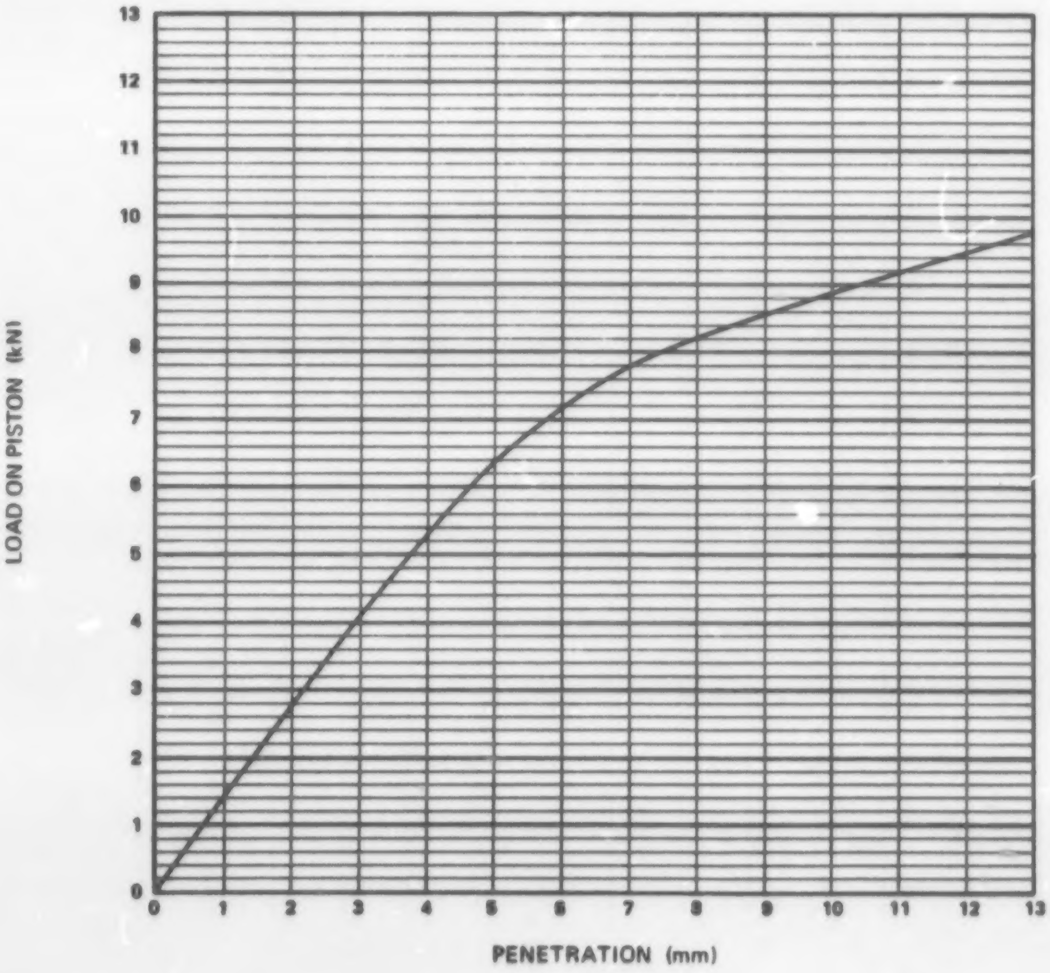
FLYASH %

California Bearing Ratio: 2.5 mm 26 %

CEMENT %

5.0 mm 32 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 75% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Calgary: Bearspaw

Sand 24% , Silt 51% , Clay 25%

Initial Dry Density: 1643 kg/m^3

Initial Moisture Content: 22.0 %

Stabilizer Dosage: FUJIBETON 4 %

Final Moisture Content: 20.7 %

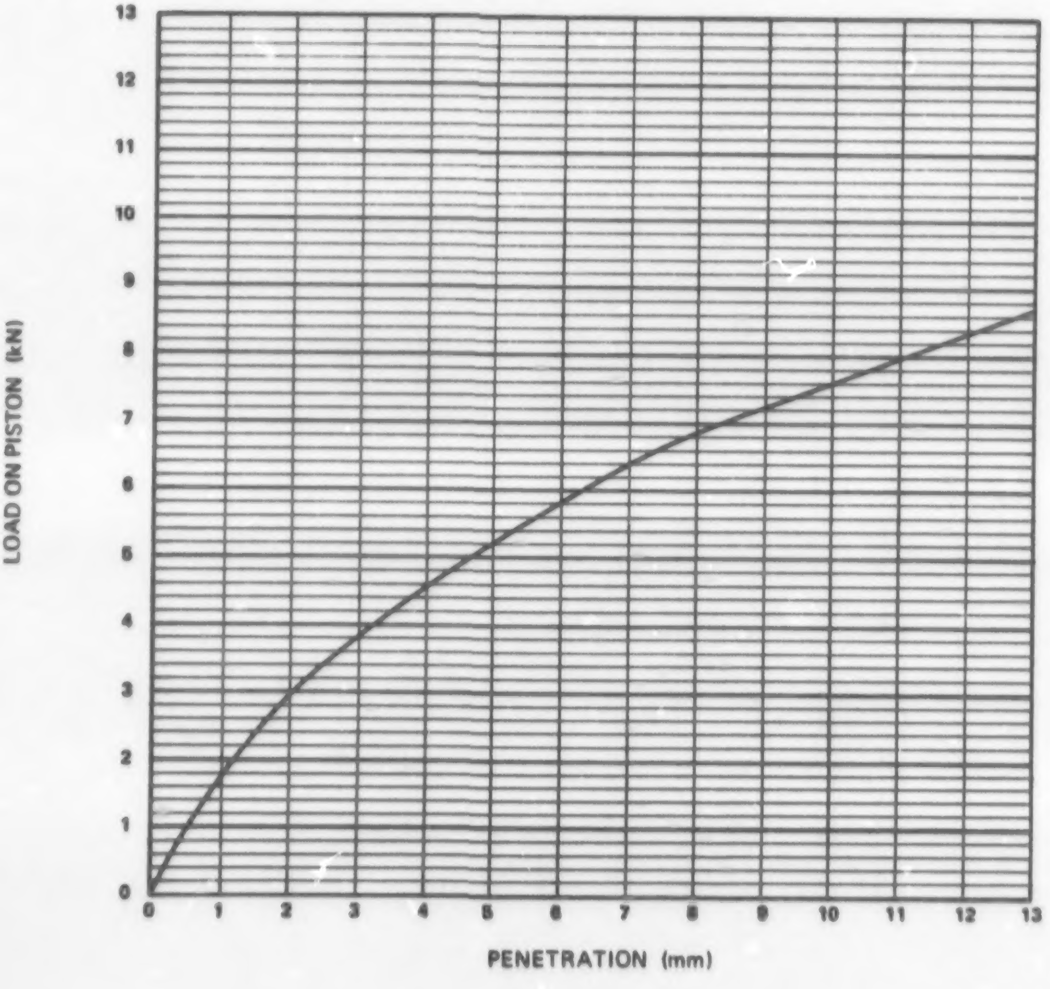
FLYASH %

California Bearing Ratio: 2.5 mm 25 %

CEMENT %

5.0 mm 26 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 100% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Calgary: Bearspaw

Sand 24%, Silt 51%, Clay 25%

Initial Dry Density: 1673 kg/m^3

Initial Moisture Content: 16.3 %

Stabilizer Dosage: FUJIBETON 4 %

Final Moisture Content: 22.8 %

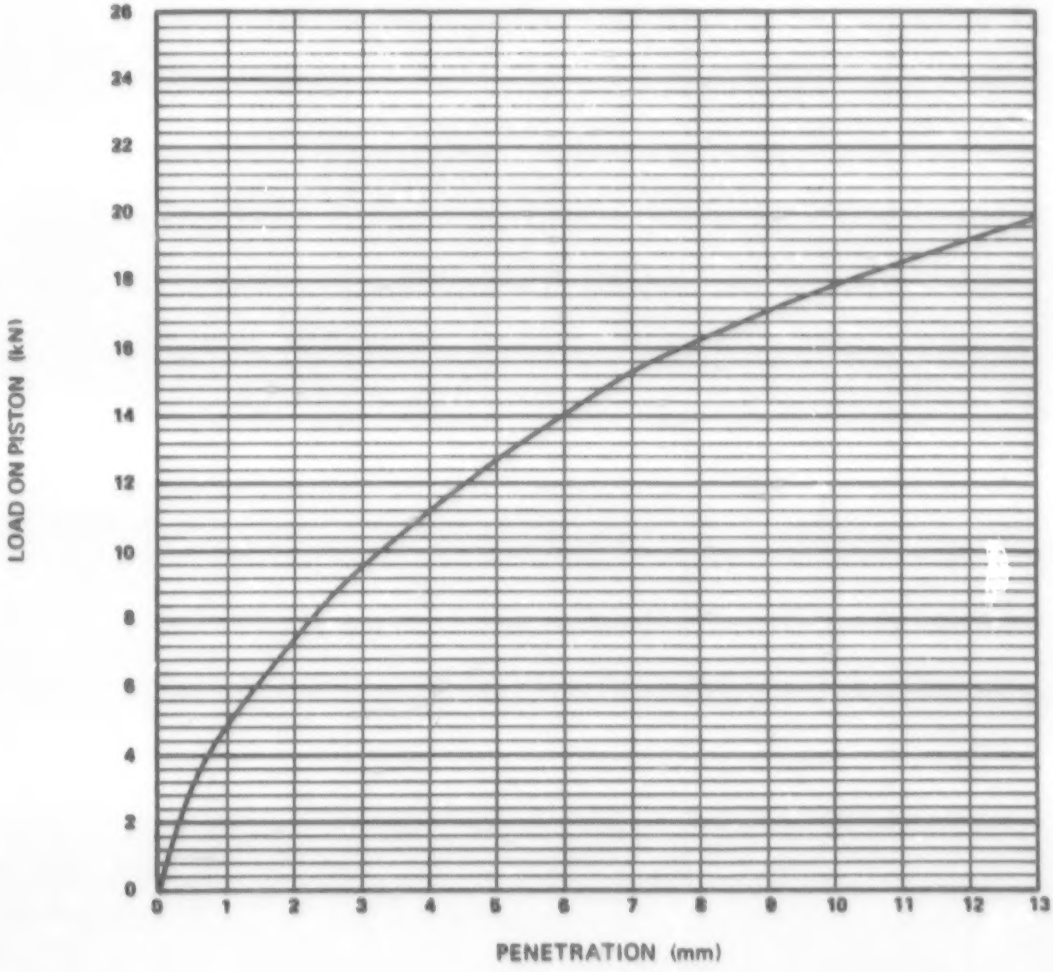
FLYASH %

California Bearing Ratio: 2.5 mm 67 %

CEMENT %

5.0 mm 64 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 75% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Calgary: Bearspaw

Sand 24%, Silt 51%, Clay 25%

Initial Dry Density: 1657 kg/m^3

Initial Moisture Content: 22.0 %

Stabilizer Dosage: FUJIBETON 7 %

Final Moisture Content: 23.2 %

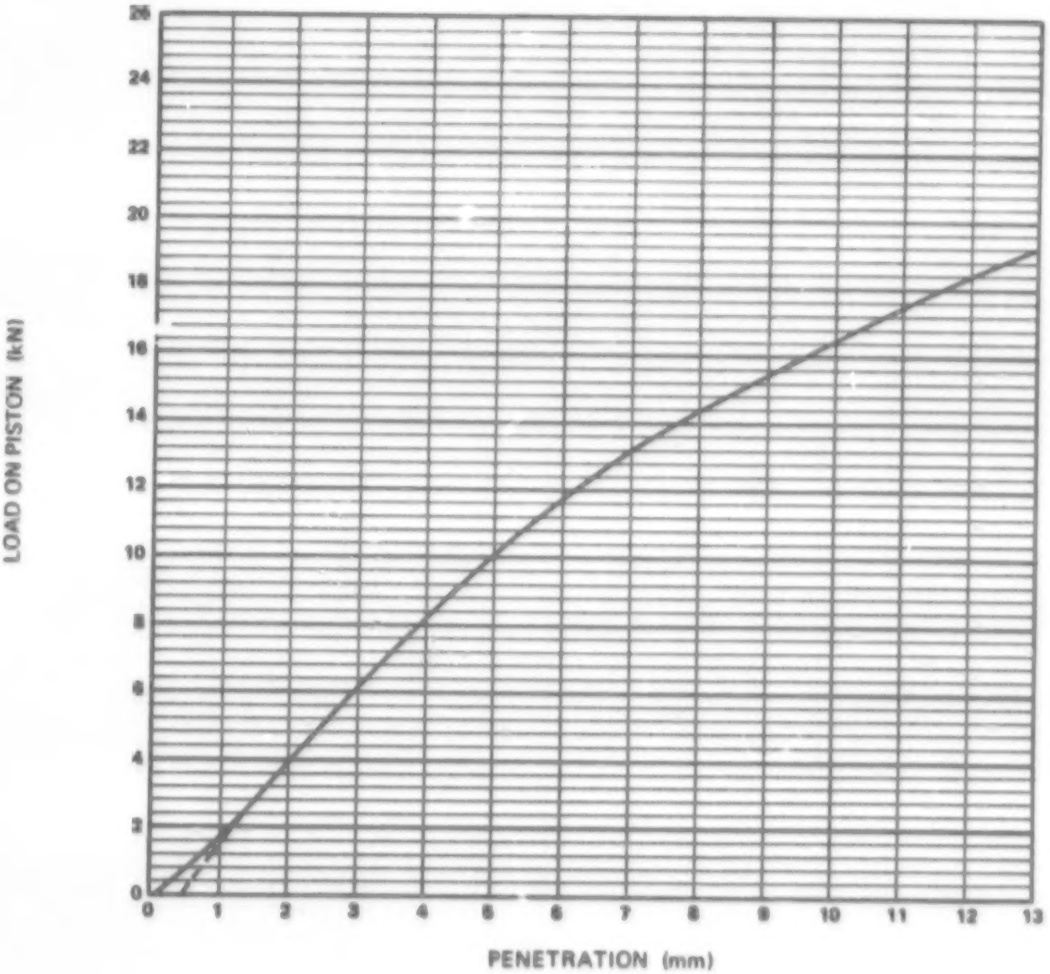
FLYASH %

California Bearing Ratio: 2.5 mm 47 %

CEMENT %

5.0 mm 55 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 100% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



EBA Engineering Consultants Ltd.

eba

CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 · 00026

Project No.: 314 · 1264.02

Sample: Calgary: Bearspaw

Sand 24% , Silt 51% , Clay 25%

Initial Dry Density: 1675 kg/m^3

Initial Moisture Content: 15.9 %

Final Moisture Content: 20.1 %

Stabilizer Dosage: FUJIBETON 7 %

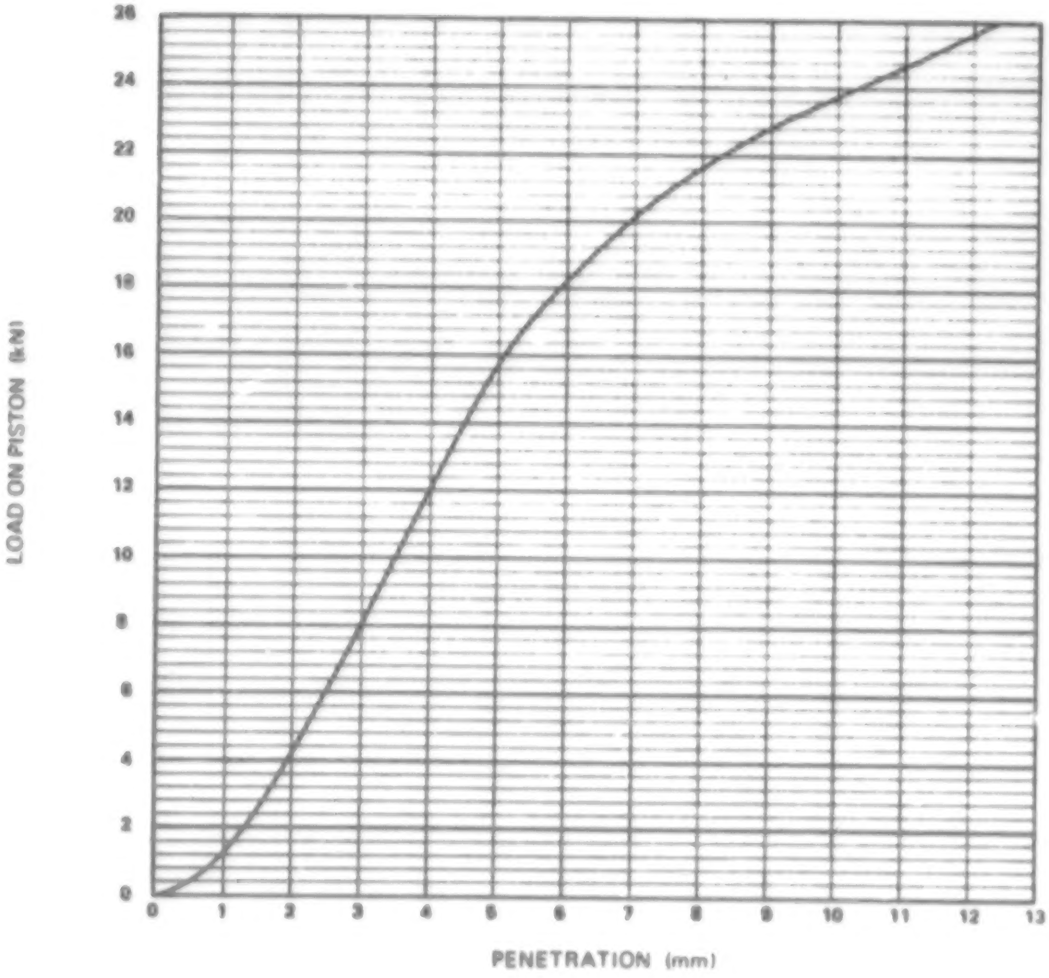
FLYASH %

CEMENT %

California Bearing Ratio 2.5 mm: 67 %

5.0 mm: 89 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 75% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Calgary: Bearspaw

Sand 24%, Silt 51%, Clay 25%

Initial Dry Density: 1681 kg/m^3

Initial Moisture Content: 18.9 %

Stabilizer Dosage: FUJIBETON 9 %

Final Moisture Content: 16.9 %

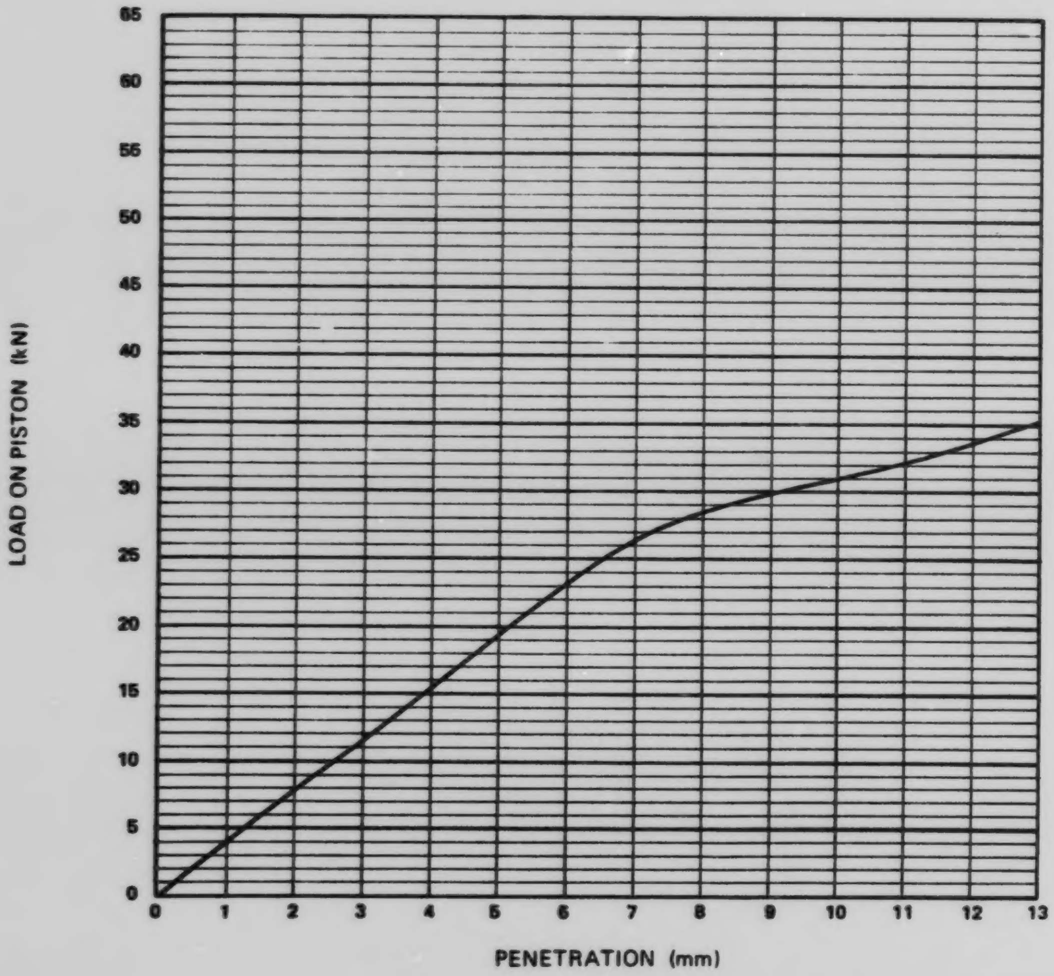
FLYASH %

California Bearing Ratio: 2.5 mm 73 %

CEMENT %

5.0 mm 97 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 100% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Calgary: Bearspaw

Sand 24% , Silt 51% , Clay 25%

Initial Dry Density: 1667 kg/m^3

Initial Moisture Content: 16.9 %

Stabilizer Dosage: FUJIBETON 9 %

Final Moisture Content: 19.3 %

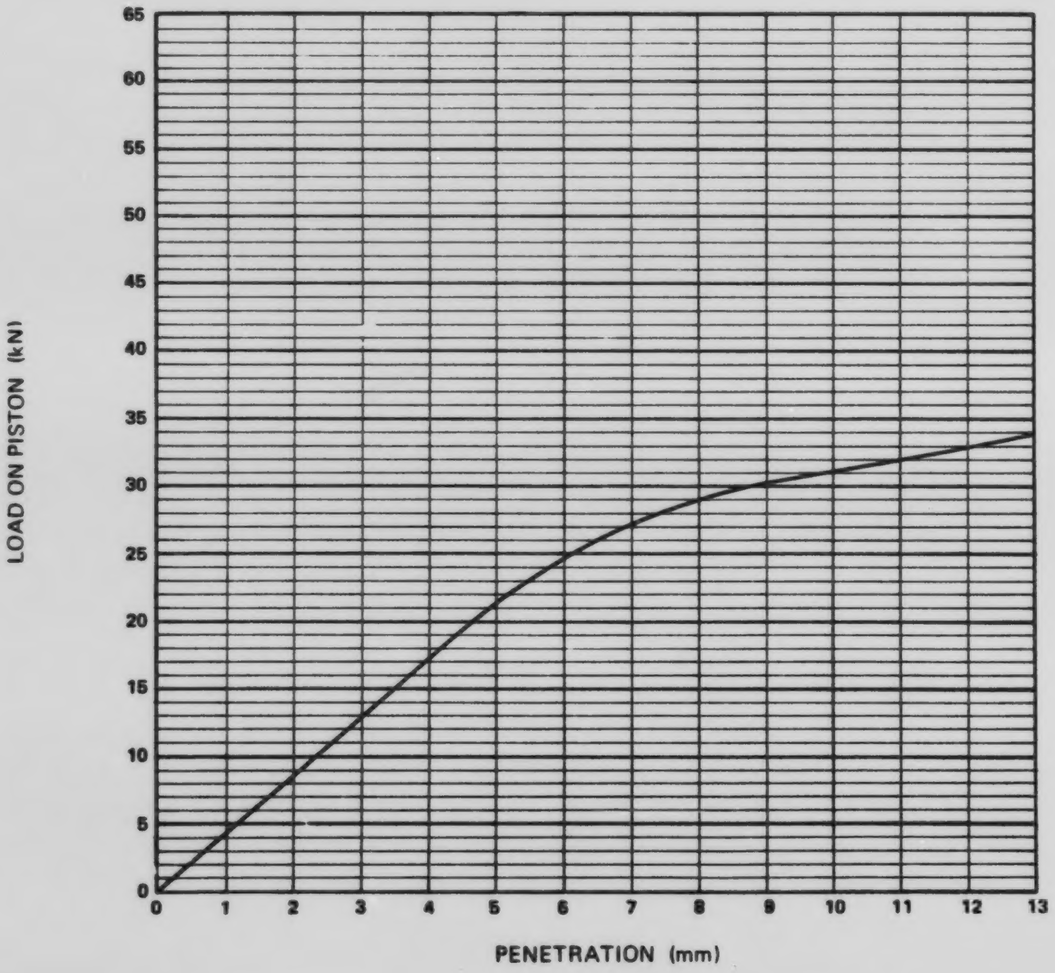
FLYASH %

California Bearing Ratio: 2.5 mm 80 %

CEMENT %

5.0 mm 102 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 75% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Calgary: Bearspaw

Sand 24%, Silt 51%, Clay 25%

Initial Dry Density: 1681 kg/m^3

Initial Moisture Content: 18.7 %

Stabilizer Dosage: FUJIBETON 12 %

Final Moisture Content: 21.5 %

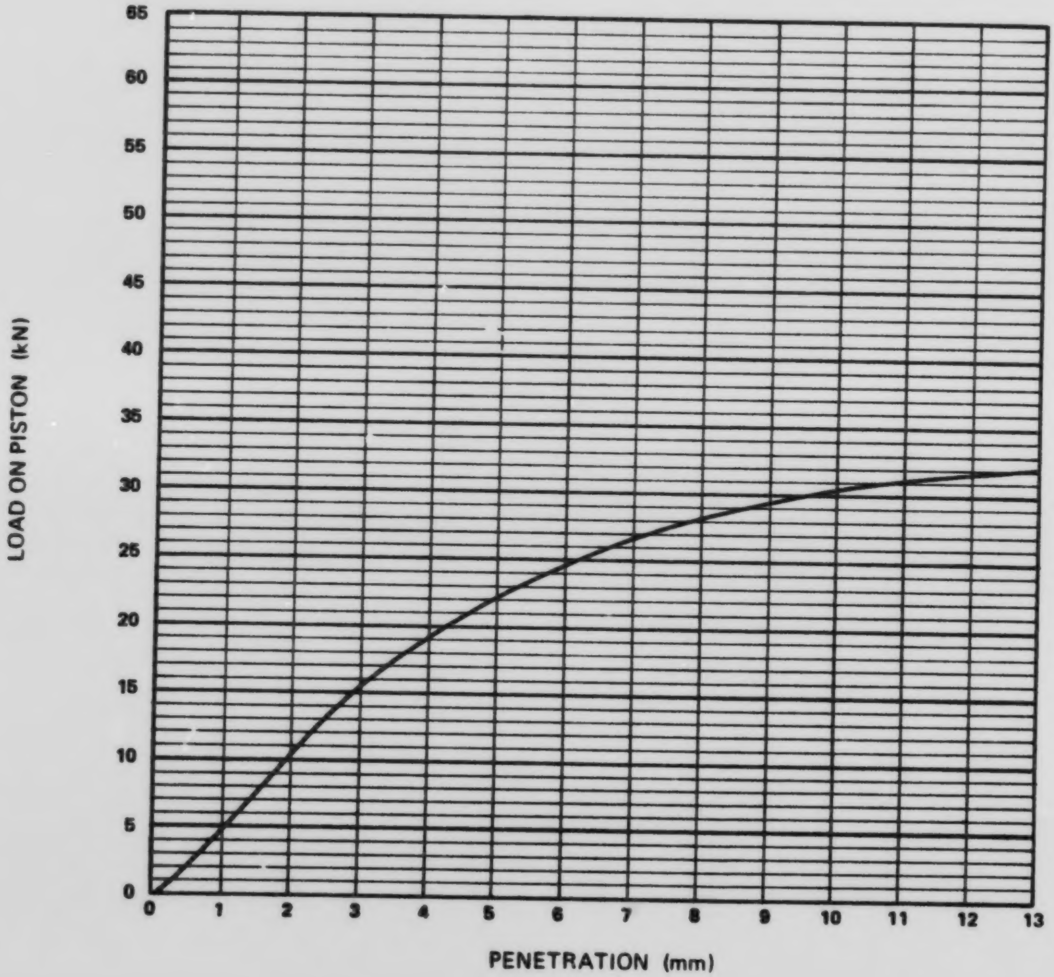
FLYASH %

California Bearing Ratio: 2.5 mm 99 %

CEMENT %

5.0 mm 111 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 100% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Calgary: Bearspaw

Sand 24%, Silt 51%, Clay 25%

Initial Dry Density: 1682 kg/m^3

Initial Moisture Content: 16.4 %

Stabilizer Dosage: FUJIBETON 12 %

Final Moisture Content: 19.5 %

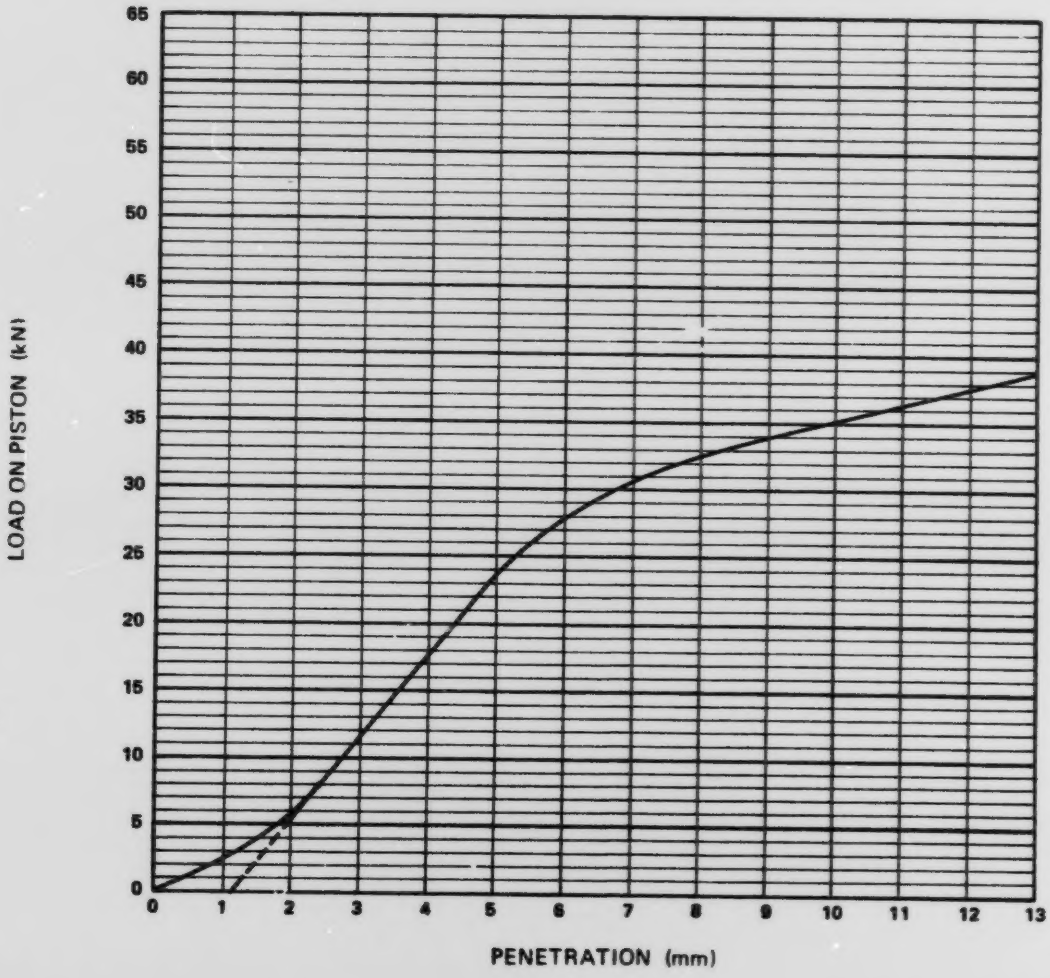
FLYASH %

California Bearing Ratio: 2.5 mm 112 %

CEMENT %

5.0 mm 140 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 75% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Calgary: Bearspaw

Sand 24% , Silt 51% , Clay 25%

Initial Dry Density: 1680 kg/m^3

Initial Moisture Content: 17.0 %

Stabilizer Dosage: FUJIBETON ______ %

Final Moisture Content: 20.9 %

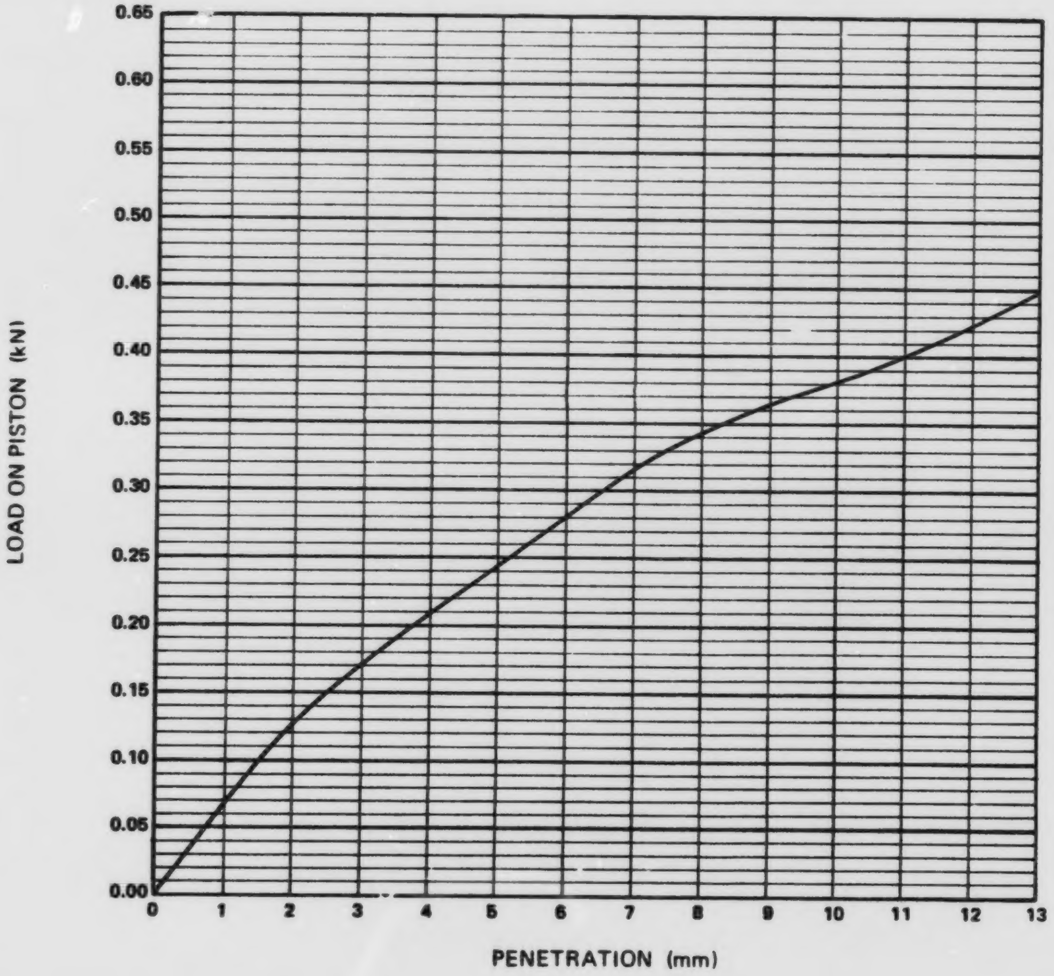
FLYASH 2 %

California Bearing Ratio: 2.5 mm 1.1 %

CEMENT ______ %

5.0 mm 1.2 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 75% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Calgary: Bearspaw

Sand 24%, Silt 51%, Clay 25%

Initial Dry Density: 1820 kg/m^3

Initial Moisture Content: 10.4 %

Stabilizer Dosage: FUJIBETON ____ %

FLYASH 6 %

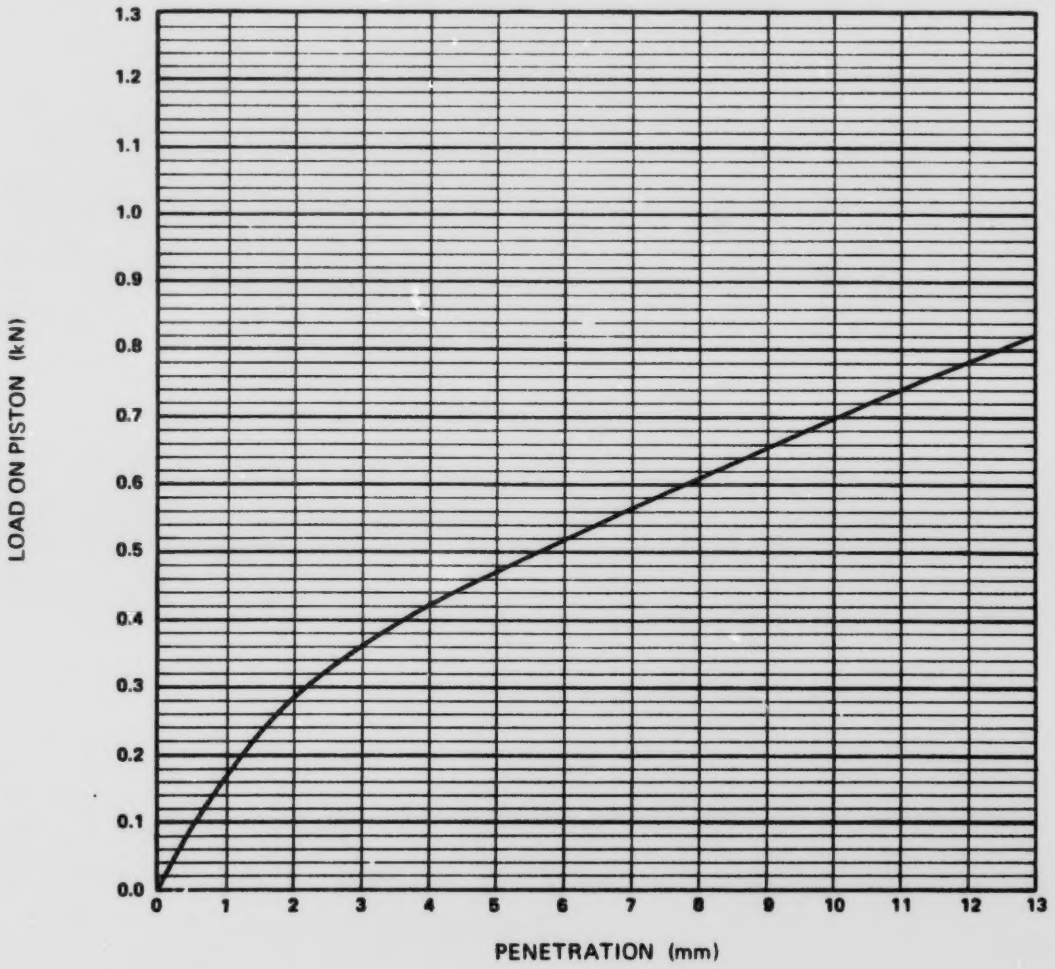
CEMENT ____ %

Final Moisture Content: 20.8 %

California Bearing Ratio: 2.5 mm 2.5 %

5.0 mm 2.3 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 100% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Calgary: Bearspaw

Sand 24%, Silt 51%, Clay 25%

Initial Dry Density: 1676 kg/m^3

Initial Moisture Content: 16.2 %

Stabilizer Dosage: FUJIBETON ____ %

FLYASH 6 %

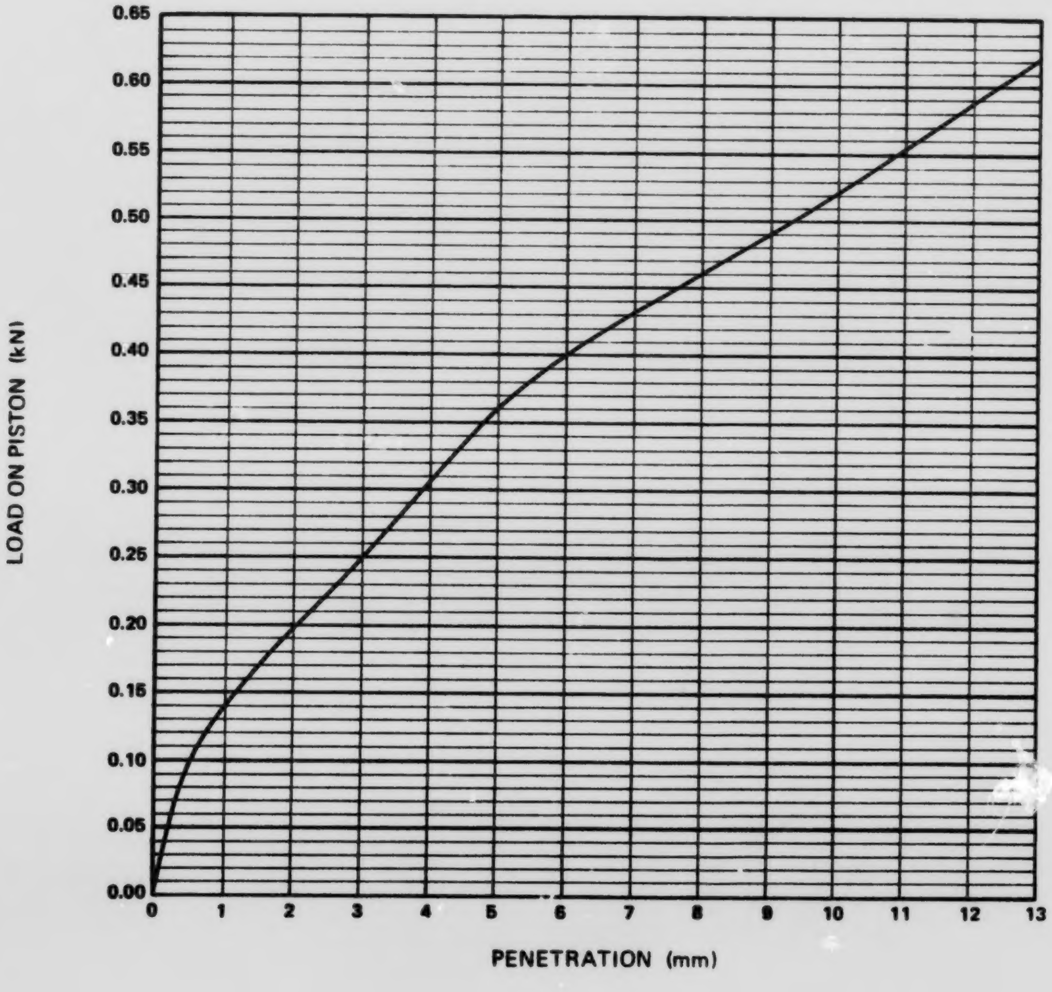
CEMENT ____ %

Final Moisture Content: 19.9 %

California Bearing Ratio: 2.5 mm 1.6 %

5.0 mm 1.8 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 75% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Calgary: Bearspaw

Sand 24% , Silt 51% , Clay 25%

Initial Dry Density: 1740 kg/m^3

Initial Moisture Content: 16.4 %

Stabilizer Dosage: FUJIBETON ____ %

FLYASH 10 %

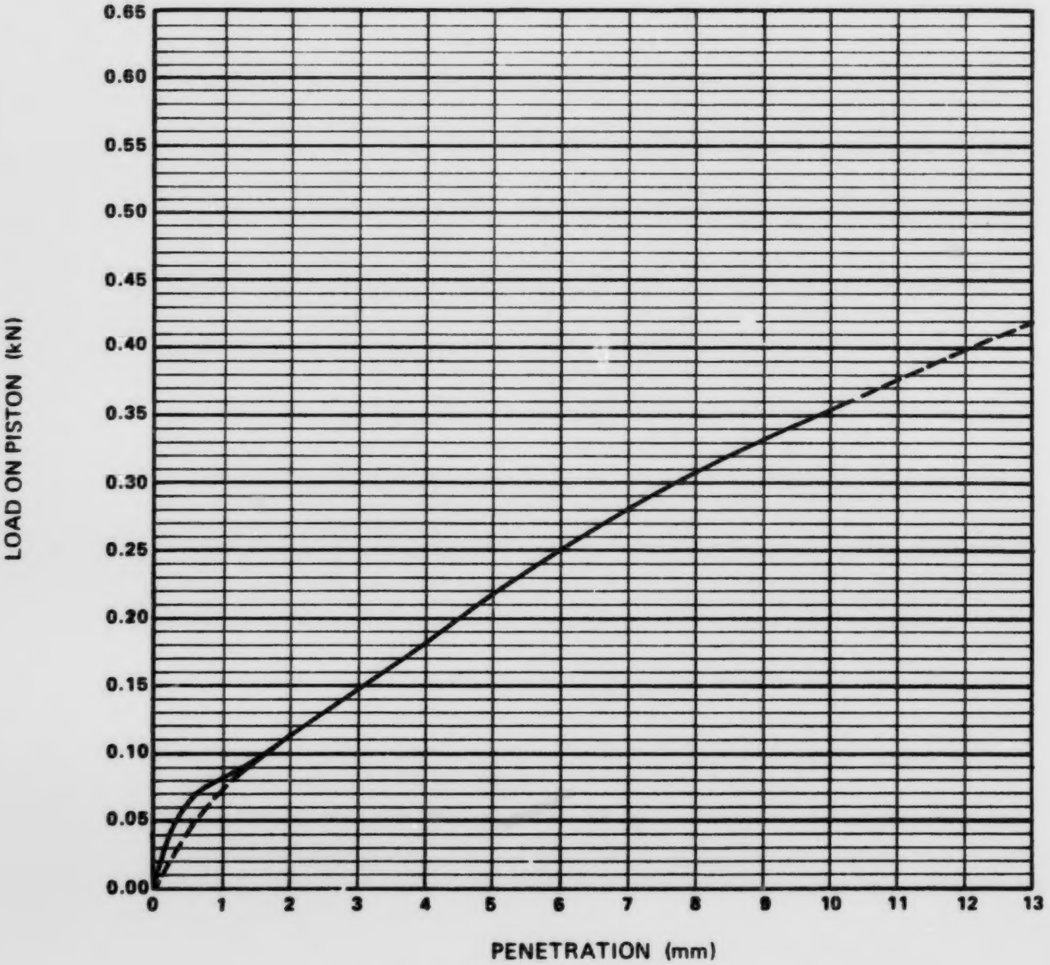
CEMENT ____ %

Final Moisture Content: 22.2 %

California Bearing Ratio: 2.5 mm 1.0 %

5.0 mm 1.1 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 100% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Calgary: Bearspaw

Sand 24% , Silt 51% , Clay 25%

Initial Dry Density: 1689 kg/m^3

Initial Moisture Content: 16.2 %

Stabilizer Dosage: FUJIBETON ____ %

FLYASH 10 %

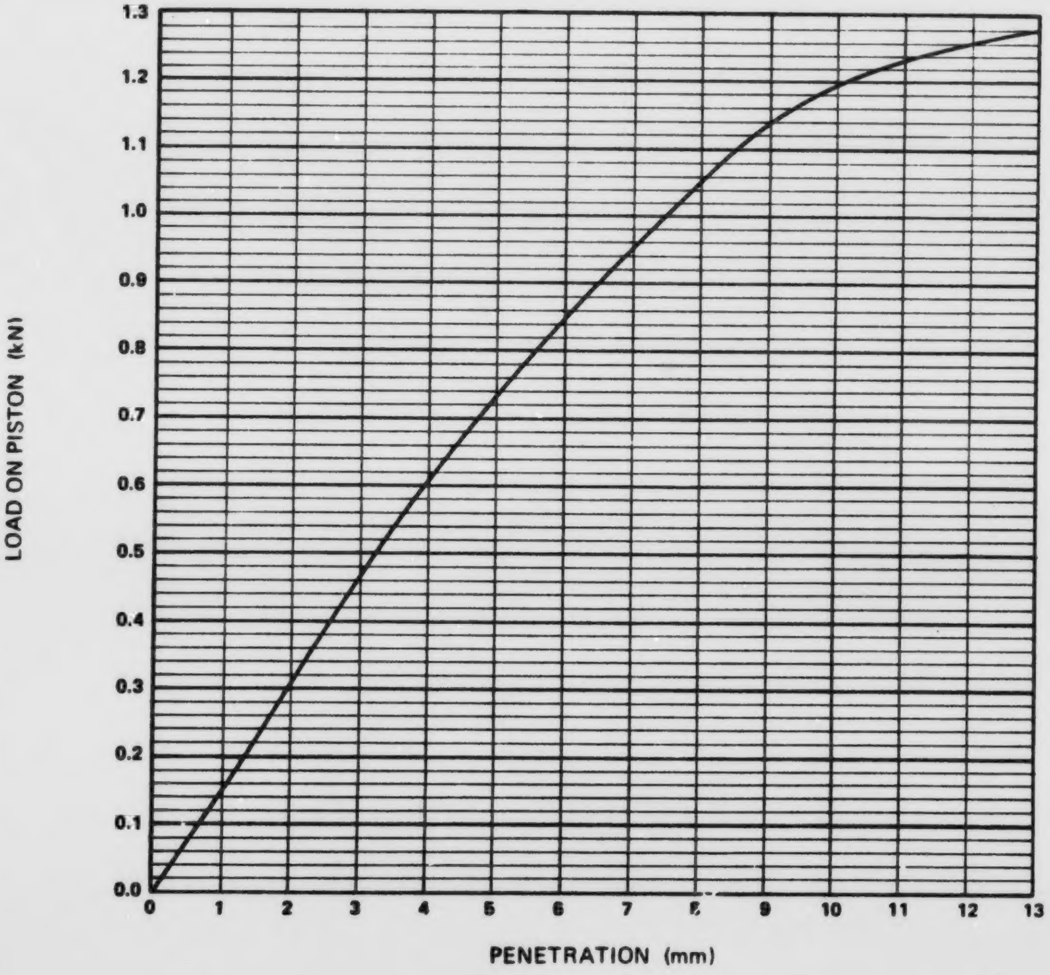
CEMENT ____ %

Final Moisture Content: 19.5 %

California Bearing Ratio: 2.5 mm 3.0 %

5.0 mm 3.6 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 75% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Calgary: Bearspaw

Sand 24% , Silt 51% , Clay 25%

Initial Dry Density: 1686 kg/m^3

Initial Moisture Content: 18.4 %

Stabilizer Dosage: FUJIBETON ______ %

Final Moisture Content: 18.2 %

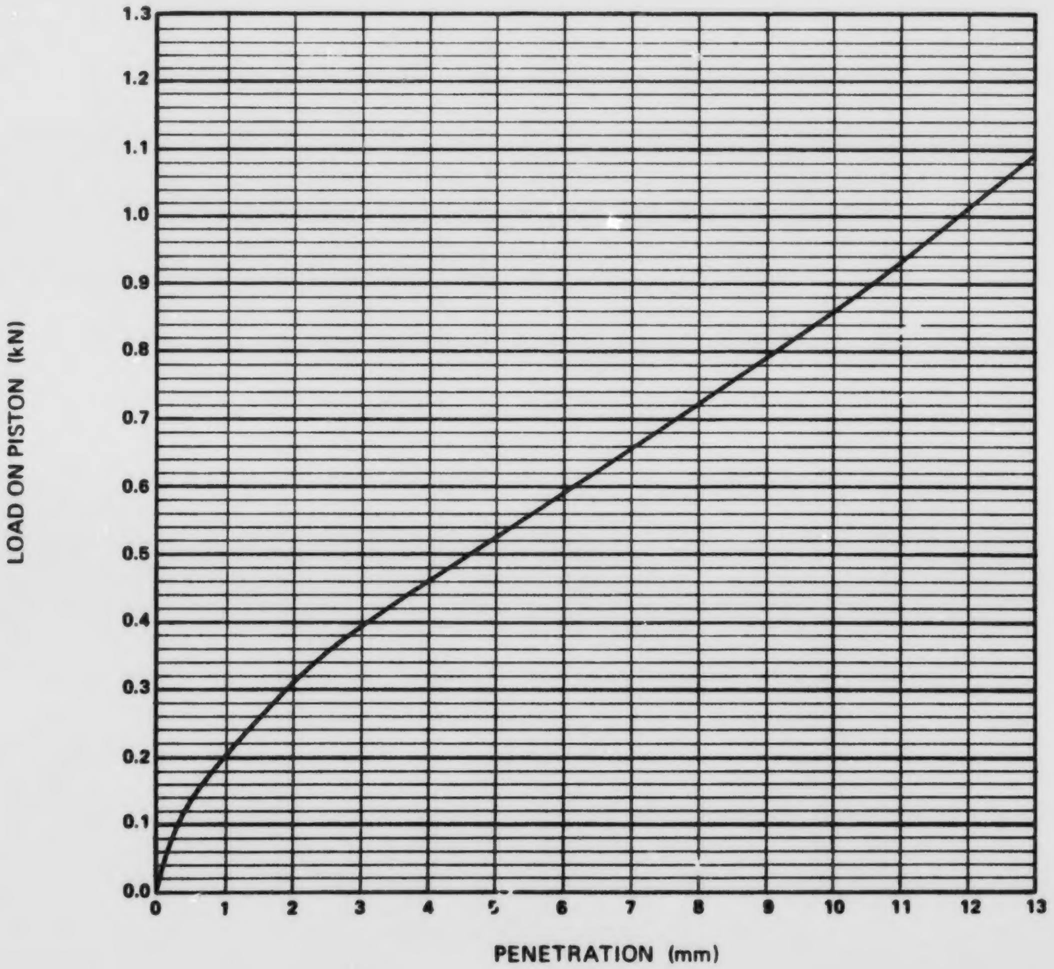
FLYASH 13 %

California Bearing Ratio: 2.5 mm 2.7 %

CEMENT ______ %

5.0 mm 2.6 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 100% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Calgary: Bearspaw

Sand 24%, Silt 51%, Clay 25%

Initial Dry Density: 1698 kg/m^3

Initial Moisture Content: 15.6 %

Stabilizer Dosage: FUJIBETON ______ %

Final Moisture Content: 19.2 %

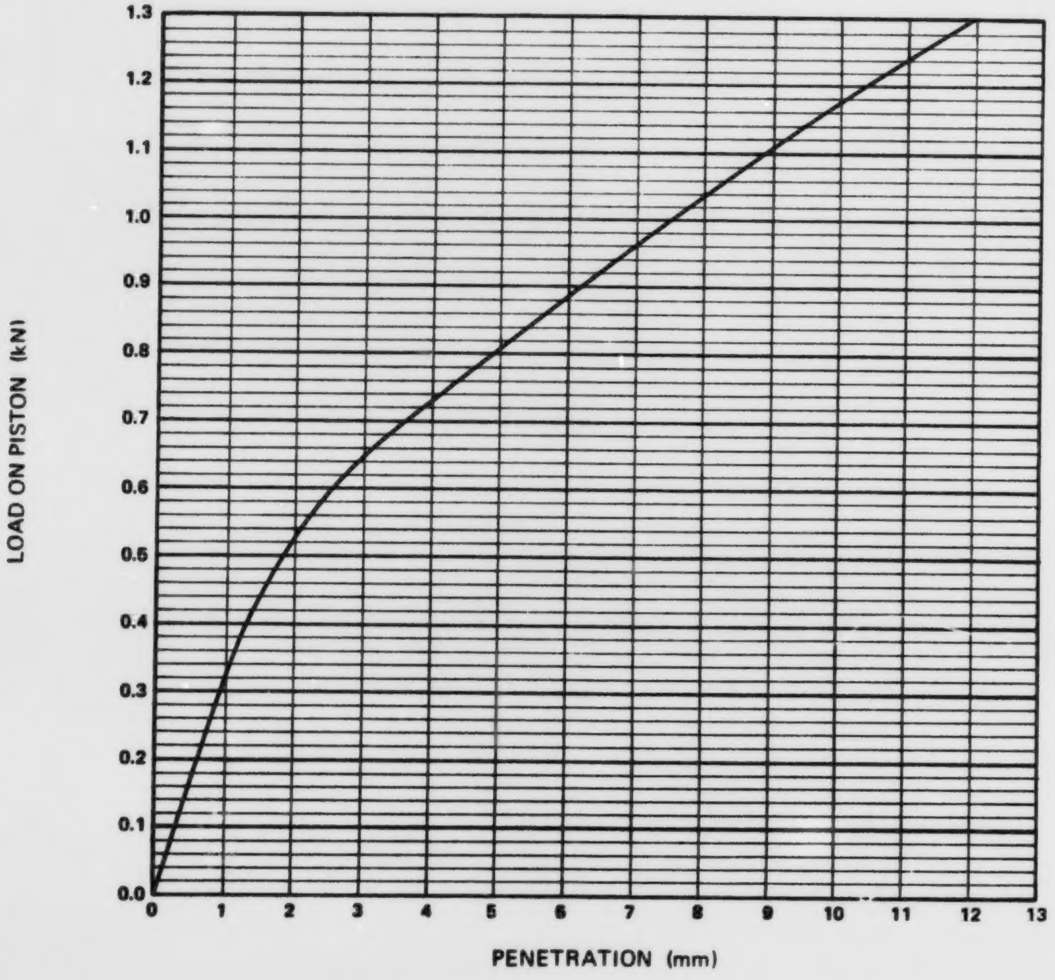
FLYASH 13 %

California Bearing Ratio: 2.5 mm 4.5 %

CEMENT ______ %

5.0 mm 4.0 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 75% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Calgary: Bearspaw

Sand 24%, Silt 51%, Clay 25%

Initial Dry Density: 1230 kg/m^3

Initial Moisture Content: 39.0 %

Final Moisture Content: 40.1 %

Stabilizer Dosage: FUJIBETON ____ %

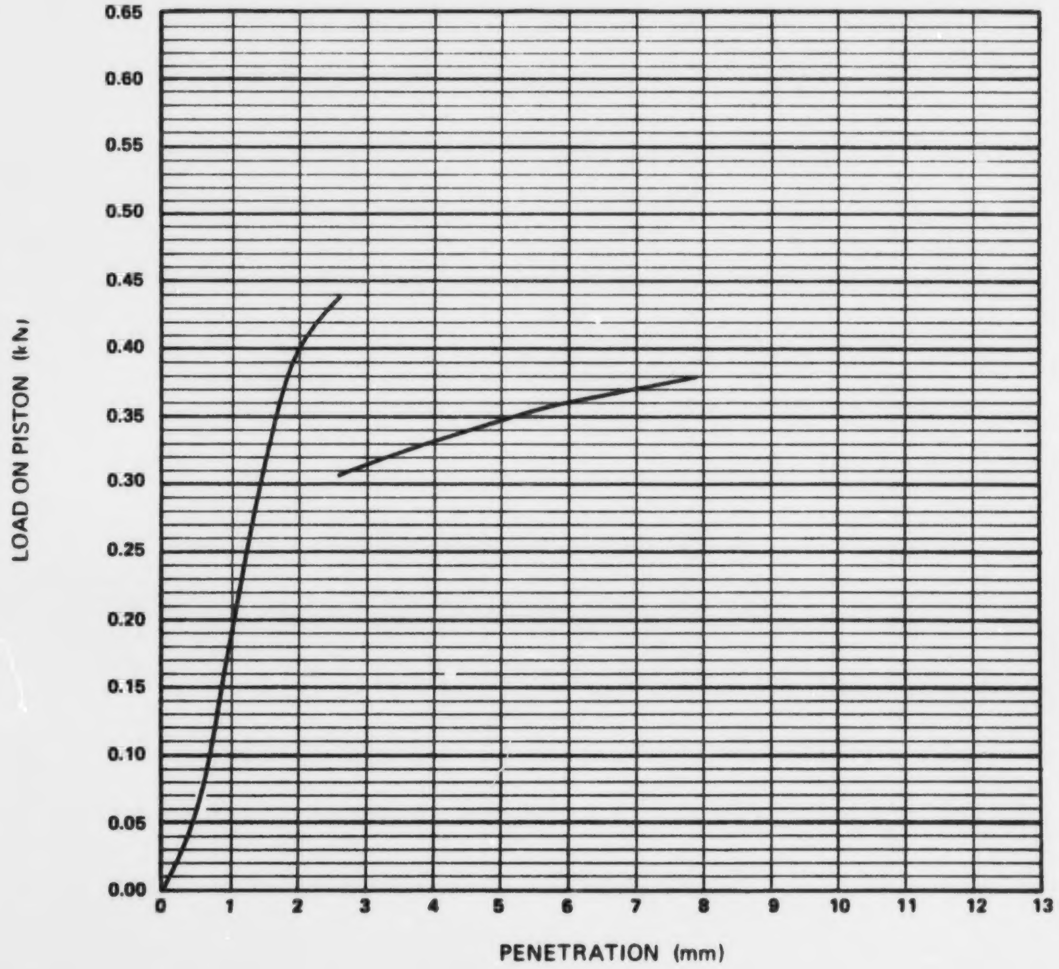
FLYASH 16 %

CEMENT ____ %

California Bearing Ratio: 2.5 mm ____

5.0 mm ____

Sample statically compacted to maximum dry density obtained during compaction test performed using 100% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Calgary: Bearspaw

Sand 24%, Silt 51%, Clay 25%

Initial Dry Density: 1690 kg/m^3

Initial Moisture Content: 18.2 %

Stabilizer Dosage: FUJIBETON ____ %

Final Moisture Content: 22.9 %

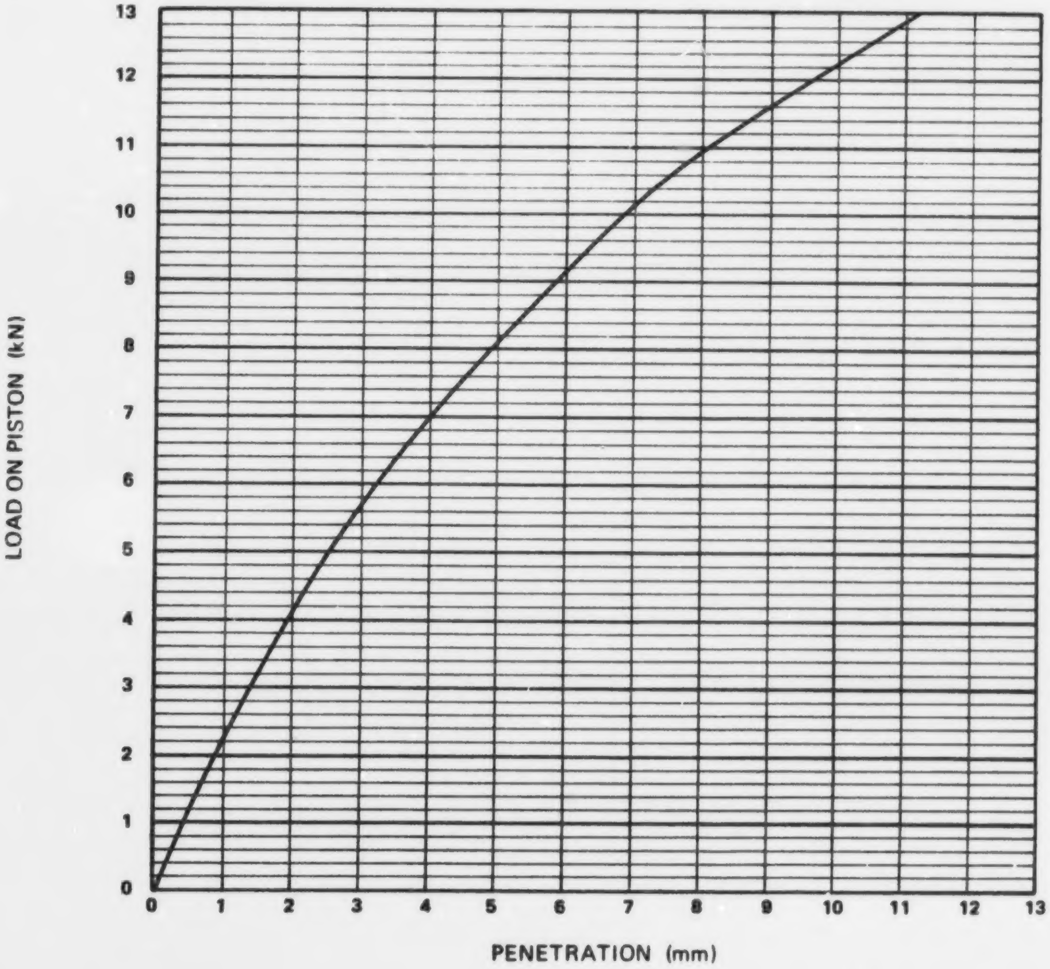
FLYASH 7 %

California Bearing Ratio: 2.5 mm 38 %

CEMENT 3 %

5.0 mm 41 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 100% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Calgary: Bearspaw

Sand 24% , Silt 51% , Clay 25%

Initial Dry Density: 1671 kg/m^3

Initial Moisture Content: 15.6 %

Stabilizer Dosage: FUJIBETON ______ %

FLYASH 7 %

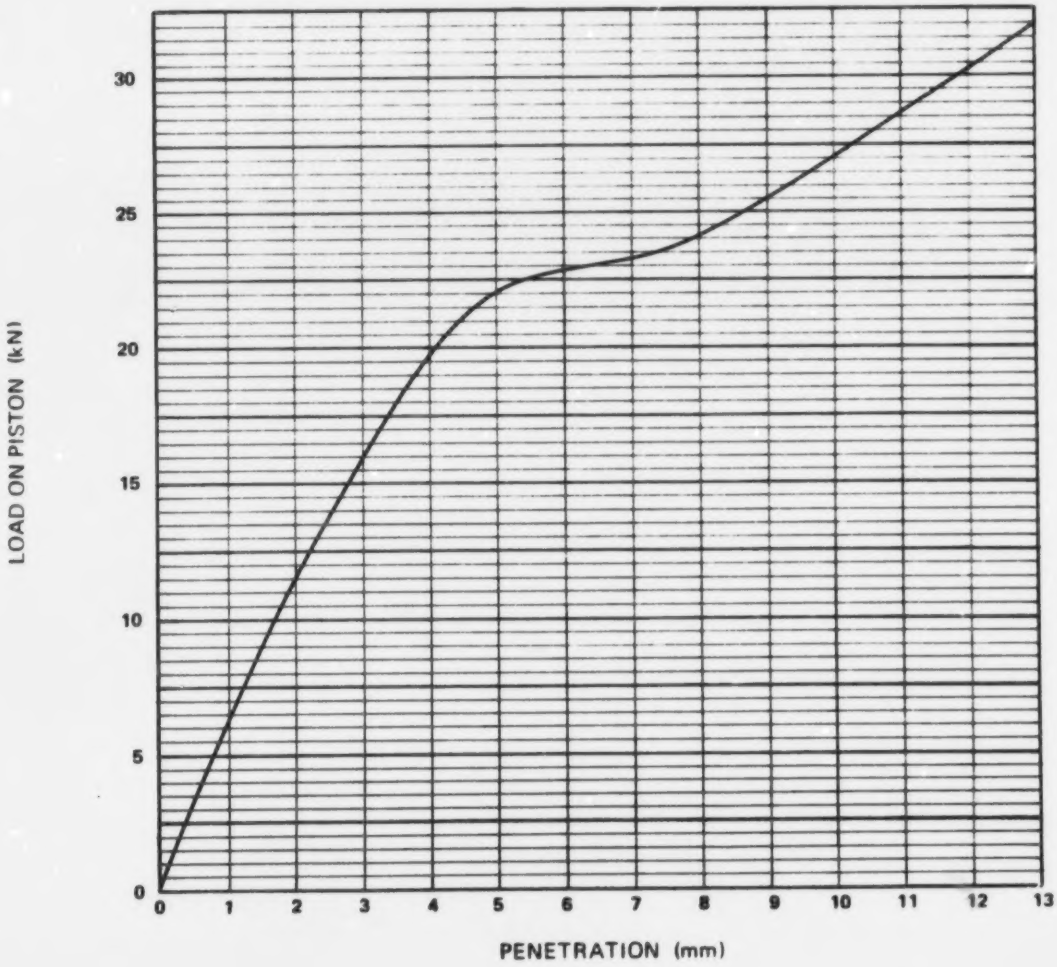
CEMENT 3 %

Final Moisture Content: 17.6 %

California Bearing Ratio 2.5 mm: 103 %

5.0 mm: 111 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 75% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA	Contract No.: 1 SD 83 - 00026
Project No.: 314 - 1264.02	Design Maximum Dry Density: 1732 kg/m³
Sample: Calgary: Bearspaw	Design Optimum Moisture Content:% 16.5 %
Sand 24 %, Silt 51 %, Clay 25 %	Initial Dry Density: 1609 kg/m³
	Initial Moisture Content: 18.0 %
	Initial Volume: 935.6 cm³
Stabilizer Dosage: FUJIBETON 2 %	Volume After Curing: 938.6 cm³
FLYASH ______ %	Final Moisture Content: 22.4 %
CEMENT ______ %	Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 559 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm³)	VOLUME AFTER DRYING AND BRUSHING (cm³)	WEIGHT AFTER DRYING AND BRUSHING (g)
1	948.0	886.2	1497.5
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during second inundation.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1683 kg/m^3

Sample: Calgary: Bearspaw

Sand 24 %, Silt 51 %, Clay 25 %

Design Optimum Moisture Content: % 16.2 %

Initial Dry Density: 1683.3 kg/m^3

Initial Moisture Content: 16.2 %

Initial Volume: 936.9 cm^3

Stabilizer Dosage: FUJIBETON 2 %

Volume After Curing: 937.2 cm^3

FLYASH %

Final Moisture Content: --- %

CEMENT %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 559 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm^3)	VOLUME AFTER DRYING AND BRUSHING (cm^3)	WEIGHT AFTER DRYING AND BRUSHING (g)
1	935.3	905.3	1574.5
2	861.8	830.4	1445.5
3	906.0	876.4	1384.2
4	908.5	738.1	1321.4
5	716.7		
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during fifth drying period.

EBA Engineering Consultants Ltd.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Project No.: 314 - 1264.02

Sample: Calgary: Bearspaw

Sand 24 %, Silt 51 %, Clay 25 %

Stabilizer Dosage: FUJIBETON 4 %

FLYASH %

CEMENT %

Contract No.: 1 SD 83 - 00026

Design Maximum Dry Density: 1720 kg/m3

Design Optimum Moisture Content:% 16.5 %

Initial Dry Density: 1628 kg/m3

Initial Moisture Content: 16.2 %

Initial Volume: 925.8 cm3

Volume After Curing: 927.6 cm3

Final Moisture Content: --- %

Stabilized Soil Loss: 17 %

Method of Sample Preparation: ASTM D 559 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm3)	VOLUME AFTER DRYING AND BRUSHING (cm3)	WEIGHT AFTER DRYING AND BRUSHING (g)
1	934.2	901.3	1512.7
2	914.6	910.9	1522.8
3	910.7	918.2	1481.4
4	903.1	845.3	1477.8
5	856.4	840.1	1450.5
6	926.2	825.6	1418.5
7	866.1	827.5	1400.4
8	884.2	867.9	1384.0
9	832.1	825.6	1371.9
10	805.9	779.6	1335.0
11	779.3	778.0	1313.3
12	777.2	788.5	1289.2

Remarks: Unconfined Compressive Strength after durability test determined as 3.6 MPa.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Project No.: 314 - 1264.02

Sample: Calgary: Bearspaw

Sand 24 %, Silt 51 %, Clay 25 %

Stabilizer Dosage: FUJIBETON 4 %

FLYASH %

CEMENT %

Contract No.: 1 SD 83 - 00026

Design Maximum Dry Density: 1674 kg/m^3

Design Optimum Moisture Content:% 16.3 %

Initial Dry Density: 1669 kg/m^3

Initial Moisture Content: 16.6 %

Initial Volume: 934.0 cm^3

Volume After Curing: 930.3 cm^3

Final Moisture Content: --- %

Stabilized Soil Loss: 21 %

Method of Sample Preparation: ASTM D 559 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm^3)	VOLUME AFTER DRYING AND BRUSHING (cm^3)	WEIGHT AFTER DRYING AND BRUSHING (g)
1	938.3	919.5	1569.9
2	917.6	910.2	1543.0
3	903.0	904.7	1512.3
4	900.3	858.0	1502.1
5	853.1	849.6	1479.7
6	897.8	873.1	1441.5
7	867.8	833.5	1421.4
8	849.2	874.6	1396.3
9	921.2	888.2	1345.6
10	916.0	910.4	1315.3
11	906.1	908.2	1259.4
12	884.7	903.5	1249.0

Remarks: Unconfined Compressive Strength after durability test determined as 3.3 MPa.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1720 kg/m^3

Sample: Calgary: Bearspaw

Design Optimum Moisture Content:% 16.5 %

Sand 24 %, Silt 51 %, Clay 25 %

Initial Dry Density: 1624 kg/m^3

Initial Moisture Content: 16.7 %

Initial Volume: 925.7 cm^3

Stabilizer Dosage: FUJIBETON 7 %

Volume After Curing: 939.2 cm^3

FLYASH %

Final Moisture Content: 22.9 %

CEMENT %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 559 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm^3)	VOLUME AFTER DRYING AND BRUSHING (cm^3)	WEIGHT AFTER DRYING AND BRUSHING (g)
1	937.3	907.8	1534.2
2	919.5	906.4	1558.6
3	921.4	906.3	1514.0
4	928.7	902.3	1521.7
5	744.7	769.5	1285.5
6	719.0	729.1	1206.6
7	696.2	646.7	1143.2
8	690.5	693.7	1035.5
9	625.2		
10			
11			
12			

Remarks: Sample disintegrated during ninth drying period.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client:	TRANSPORT CANADA	Contract No.:	1 SD 83 - 00026
Project No.:	314 - 1264.02	Design Maximum Dry Density:	1675 kg/m³
Sample:	Calgary: Bearspaw	Design Optimum Moisture Content:%	16.2 %
	Sand 24 %, Silt 51 %, Clay 25 %	Initial Dry Density:	1675 kg/m³
		Initial Moisture Content:	16.2 %
		Initial Volume:	938.1 cm³
Stabilizer Dosage: FUJIBETON	7 %	Volume After Curing:	945.0 cm³
FLYASH	%	Final Moisture Content:	--- %
CEMENT	%	Stabilized Soil Loss:	7.9 %

Method of Sample Preparation: ASTM D 559 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm³)	VOLUME AFTER DRYING AND BRUSHING (cm³)	WEIGHT AFTER DRYING AND BRUSHING (g)
1	957.6	903.7	1585.5
2	925.2	919.6	1600.9
3	923.6	919.3	1573.3
4	919.8	894.2	1574.6
5	912.4	879.4	1585.5
6	919.2	904.3	1544.4
7	904.0	902.8	1544.4
8	907.9	905.3	1529.3
9	910.8	909.2	1502.1
10	921.2	917.2	1483.5
11	921.9	910.9	1494.0
12	922.6	912.6	1481.0

Remarks: Unconfined Compressive Strength after durability test not determined due to sample shape.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA	Contract No.: 1 SD 83 - 00026
Project No.: 314 - 1264.02	Design Maximum Dry Density: 1715 kg/m³
Sample: Calgary: Bearspaw	Design Optimum Moisture Content: % 16.5 %
Sand 24 %, Silt 51 %, Clay 25 %	Initial Dry Density: 1610 kg/m³
	Initial Moisture Content: 17.0 %
	Initial Volume: 936.8 cm³
Stabilizer Dosage: FUJIBETON 9 %	Volume After Curing: 920.1 cm³
FLYASH %	Final Moisture Content: --- %
CEMENT %	Stabilized Soil Loss: 5.2 %

Method of Sample Preparation: ASTM D 559 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm³)	VOLUME AFTER DRYING AND BRUSHING (cm³)	WEIGHT AFTER DRYING AND BRUSHING (g)
1	918.4	904.8	1528.1
2	917.7	800.0	1554.9
3	903.6	913.2	1519.2
4	899.9	886.4	1530.4
5	905.1	900.8	1596.7
6	918.9	873.7	1566.0
7	910.5	880.5	1567.8
8	876.5	910.9	1557.9
9	903.9	905.4	1576.6
10	868.1	920.6	1546.1
11	890.4	896.8	1565.3
12	914.7	899.8	1561.0

Remarks: Unconfined Compressive Strength after durability test determined as 8.1 MPa.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1716 kg/m3

Sample: Calgary: Bearspaw

Sand 24 %, Silt 51 %, Clay 25 %

Design Optimum Moisture Content %: 17.7 %

Initial Dry Density: 1687 kg/m3

Initial Moisture Content: 16.6 %

Initial Volume: 936.5 cm3

Stabilizer Dosage: FUJIBETON 9 %

FLYASH %

CEMENT %

Volume After Curing: 939.1 cm3

Final Moisture Content: 18.1 %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 559 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm3)	VOLUME AFTER DRYING AND BRUSHING (cm3)	WEIGHT AFTER DRYING AND BRUSHING (g)
1	937.9	915.7	1575.9
2	925.5	918.2	1624.3
3	916.9	920.0	1625.5
4	920.7	900.8	1596.7
5	907.4	902.1	1515.4
6	918.8	883.3	1472.0
7	872.7	874.1	1462.6
8	894.4	880.2	1442.9
9	830.2	821.3	1386.1
10			
11			
12			

Remarks: Sample disintegrated during tenth inundation.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1720 kg/m^3

Sample: Calgary: Bearspaw

Sand 24 %, Silt 51 %, Clay 25 %

Design Optimum Moisture Content:% 16.0 %

Initial Dry Density: 1625 kg/m^3

Initial Moisture Content: 15.9 %

Initial Volume: 943.2 cm^3

Stabilizer Dosage: FUJIBETON 12 %

FLYASH %

CEMENT %

Volume After Curing: 927.5 cm^3

Final Moisture Content: --- %

Stabilized Soil Loss: 5.3 %

Method of Sample Preparation: ASTM D 559 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm^3)	VOLUME AFTER DRYING AND BRUSHING (cm^3)	WEIGHT AFTER DRYING AND BRUSHING (g)
1	929.1	900.1	1538.6
2	918.6	914.4	1585.0
3	913.5	912.4	1535.9
4	894.9	900.9	1562.3
5	901.5	892.7	1545.7
6	912.1	911.5	1529.6
7	912.2	901.1	1538.0
8	894.7	911.9	1516.5
9	911.3	904.2	1543.8
10	915.3	901.6	1505.3
11	908.7	910.9	1500.4
12	915.5	910.0	1496.7

Remarks: Unconfined Compressive Strength after durability test determined as 7.3 MPa.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 · 00026

Project No.: 314 · 1264.02

Design Maximum Dry Density: 1690 kg/m³

Sample: Calgary: Bearspaw

Sand 24 % , Silt 51 % , Clay 25 %

Design Optimum Moisture Content:% 16.5 %

Initial Dry Density: 1675 kg/m³

Initial Moisture Content: 16.7 %

Initial Volume: 938.0 cm³

Stabilizer Dosage: FUJIBETON 12 %

Volume After Curing: 936.1 cm³

FLYASH %

Final Moisture Content: --- %

CEMENT %

Stabilized Soil Loss: 15 %

Method of Sample Preparation: ASTM D 559 · 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm³)	VOLUME AFTER DRYING AND BRUSHING (cm³)	WEIGHT AFTER DRYING AND BRUSHING (g)
1	937.8	905.4	1600.7
2	926.8	921.2	1623.9
3	924.2	920.8	1592.9
4	928.6	879.6	1597.9
5	899.6	899.9	1605.1
6	904.2	904.3	1592.4
7	921.0	920.8	1584.3
8	904.2	918.1	1579.2
9	876.5	913.5	1445.4
10	861.0	903.1	1406.8
11	904.6	867.4	1397.0
12	841.3	837.3	1368.4

Remarks: Unconfined Compressive Strength after durability test determined as 0.62 MPa.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1722 kg/m3

Sample: Calgary: Bearspaw

Design Optimum Moisture Content:% 16.7 %

Sand 24 %, Silt 51 %, Clay 25 %

Initial Dry Density: 1644 kg/m3

Initial Moisture Content: 15.3 %

Initial Volume: 926.7 cm3

Stabilizer Dosage FUJIBETON ______ %

Volume After Curing: 932.2 cm3

FLYASH 2 %

Final Moisture Content: --- %

CEMENT ______ %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 559 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm^3)	VOLUME AFTER DRYING AND BRUSHING (cm^3)	WEIGHT AFTER DRYING AND BRUSHING (g)
1	932.1	895.3	1508.7
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during second inundation.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 · 00026

Project No.: 314 · 1264.02

Design Maximum Dry Density: 1710 kg/m³

Sample: Calgary: Bearspaw

Sand 24 %, Silt 51 %, Clay 25 %

Design Optimum Moisture Content:% 15.7 %

Initial Dry Density: 1694 kg/m³

Initial Moisture Content: 17.1 %

Initial Volume: 929.9 cm³

Volume After Curing: 932.9 cm³

Final Moisture Content: --- %

Stabilized Soil Loss: 100 %

Stabilizer Dosage:
FUJIBETON ____ %
FLYASH 2 %
CEMENT ____ %

Method of Sample Preparation: ASTM D 559 · 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm³)	VOLUME AFTER DRYING AND BRUSHING (cm³)	WEIGHT AFTER DRYING AND BRUSHING (g)
1	940.8	877.8	1576.5
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during second inundation.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1725 kg/m3

Sample: Calgary: Bearspaw

Design Optimum Moisture Content:% 15.0 %

Sand 24 %, Silt 51 %, Clay 25 %

Initial Dry Density: 1619 kg/m3

Initial Moisture Content: 14.7 %

Initial Volume: 891.1 cm3

Stabilizer Dosage: FUJIBETON %

Volume After Curing: 898.4 cm3

FLYASH 6 %

Final Moisture Content: --- %

CEMENT %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 559 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm³)	VOLUME AFTER DRYING AND BRUSHING (cm³)	WEIGHT AFTER DRYING AND BRUSHING (g)
1	912.6	855.8	1426.2
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during second inundation.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 00028

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1597 kg m^3

Sample: Calgary: Bearspaw

Design Optimum Moisture Content %: 16.0 %

Sand 24 %, Silt 51 %, Clay 25 %

Initial Dry Density: 1683 kg m^3

Initial Moisture Content: 16.2 %

Initial Volume: 943.3 cm^3

Stabilizer Dosage: FUJIBETON %

Volume After Curing: 936.5 cm^3

FLYASH 6 %

Final Moisture Content: --- %

CEMENT %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 559 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA

CYCLE	VOLUME AFTER SOAKING (cm^3)	VOLUME AFTER DRYING AND BRUSHING (cm^3)	WEIGHT AFTER DRYING AND BRUSHING (g)
1	946.6	737.0	1436.0
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during second inundation.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1752 kg/m3

Sample: Calgary: Bearspaw

Design Optimum Moisture Content:% 15.6 %

Sand 24 %, Silt 51 %, Clay 25 %

Initial Dry Density: 1641.0 kg/m3

Initial Moisture Content: 16.3 %

Initial Volume: 928.8 cm3

Stabilizer Dosage: FUJIBETON %

Volume After Curing: 923.8 cm3

FLYASH 10 %

Final Moisture Content: --- %

CEMENT %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 559 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm^3)	VOLUME AFTER DRYING AND BRUSHING (cm^3)	WEIGHT AFTER DRYING AND BRUSHING (g)
1	949.2	898.8	1512.5
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during second inundation.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1720 kg/m^3

Sample: Calgary: Bearspaw
Sand 24 %, Silt 51 %, Clay 25 %

Design Optimum Moisture Content:% 15.0 %

Initial Dry Density: 1719 kg/m^3

Initial Moisture Content: 15.0 %

Initial Volume: 938.5 cm^3

Stabilizer Dosage: FUJIBETON ____ %

FLYASH 10 %

CEMENT ____ %

Volume After Curing: 943.3 cm^3

Final Moisture Content: --- %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 559 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm^3)	VOLUME AFTER DRYING AND BRUSHING (cm^3)	WEIGHT AFTER DRYING AND BRUSHING (g)
1	942.3	874.9	1572.7
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during second inundation.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Project No.: 314 · 1264.02

Sample: Calgary: Bearspaw

Sand 24 %, Silt 51 %, Clay 25 %

Stabilizer Dosage: FUJIBETON %

FLYASH 13 %

CEMENT %

Contract No.: 1 SD 83 · 00026

Design Maximum Dry Density: 1728 kg/m^3

Design Optimum Moisture Content:% 15.5 %

Initial Dry Density: 1616 kg/m^3

Initial Moisture Content: 16.6 %

Initial Volume: 942.4 cm^3

Volume After Curing: 946.1 cm^3

Final Moisture Content: --- %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 559 · 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm^3)	VOLUME AFTER DRYING AND BRUSHING (cm^3)	WEIGHT AFTER DRYING AND BRUSHING (g)
1	954.6	895.5	1471.3
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during second inundation.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Project No.: 314 - 1264.02

Sample: Calgary: Bearspaw

Sand 24 %, Silt 51 %, Clay 25 %

Stabilizer Dosage: FUJIBETON %

FLYASH 13 %

CEMENT %

Contract No.: 1 SD 83 - 00026

Design Maximum Dry Density: 1735 kg/m3

Design Optimum Moisture Content:% 15.0 %

Initial Dry Density: 1708 kg/m3

Initial Moisture Content: 15.4 %

Initial Volume: 935.2 cm3

Volume After Curing: 938.6 cm3

Final Moisture Content: --- %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 559 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm3)	VOLUME AFTER DRYING AND BRUSHING (cm3)	WEIGHT AFTER DRYING AND BRUSHING (g)
1	946.7	887.6	1571.8
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during second inundation.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1725 kg/m³

Sample: Calgary: Bearspaw

Design Optimum Moisture Content: % 15.8 %

Sand 24 %, Silt 51 %, Clay 25 %

Initial Dry Density: 1620 kg/m³

Initial Moisture Content: 16.4 %

Initial Volume: 940.5 cm³

Stabilizer Dosage: FUJIBETON %

Volume After Curing: 922.7 cm³

FLYASH 7 %

Final Moisture Content: --- %

CEMENT 3 %

Stabilized Soil Loss: 8.3 %

Method of Sample Preparation: ASTM D 559 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm³)	VOLUME AFTER DRYING AND BRUSHING (cm³)	WEIGHT AFTER DRYING AND BRUSHING (g)
1	934.8	907.0	1519.2
2	929.4	916.0	1444.7
3	911.9	914.6	1390.4
4	858.6	888.8	1343.0
5	884.8	887.9	1521.6
6	907.8	882.5	1492.5
7	910.0	876.6	1485.3
8	889.2	901.0	1479.9
9	895.6	877.2	1474.2
10	898.2	887.6	1454.4
11	898.5	857.7	1458.3
12	870.9	873.2	1437.0

Remarks: Unconfined Compressive Strength after durability test determined as 3.7 MPa.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client:	TRANSPORT CANADA	Contract No.:	1 SD 83 - 00026
Project No.:	314 - 1264.02	Design Maximum Dry Density:	1658 kg/m³
Sample:	Calgary: Bearspaw	Design Optimum Moisture Content:%	16.4 %
	Sand 24 %, Silt 51 %, Clay 25 %	Initial Dry Density:	1658 kg/m³
		Initial Moisture Content:	16.4 %
		Initial Volume:	934.1 cm³
Stabilizer Dosage: FUJIBETON	%	Volume After Curing:	948.6 cm³
FLYASH	7 %	Final Moisture Content:	--- %
CEMENT	3 %	Stabilized Soil Loss:	100 %

Method of Sample Preparation: ASTM D 559 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm³)	VOLUME AFTER DRYING AND BRUSHING (cm³)	WEIGHT AFTER DRYING AND BRUSHING (g)
1	952.4	924.7	1551.2
2	927.5	917.6	1533.1
3	892.2	929.6	1487.7
4	860.9	845.7	1450.8
5	873.8	870.4	1425.0
6	902.7	878.8	1372.5
7	784.4	739.1	1338.6
8	719.4		1317.5
9			
10			
11			
12			

Remarks: Sample disintegrated during eighth drying period.

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1732 kg/m³

Sample: Calgary: Bearspaw

Sand 24 %, Silt 51 %, Clay 25 %

Design Optimum Moisture Content: 16.5 %

Initial Dry Density: 1643 kg/m³

Initial Moisture Content: 16.2 %

Initial Volume: 940.8 cm³

Stabilizer Dosage: FUJIBETON 2 %

FLYASH %

CEMENT %

Volume After Curing: --- cm³

Final Moisture Content: --- %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D560 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm³)	WEIGHT AFTER THAWING AND BRUSHING (g)
1	902.1	1584.1
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated after initial brushing

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1683 kg/m³

Sample: Calgary: Bearspaw

Sand 24 %, Silt 51 %, Clay 25 %

Design Optimum Moisture Content: 16.2 %

Initial Dry Density: 1664 kg/m³

Initial Moisture Content: 16.3 %

Initial Volume: 947.2 cm³

Stabilizer Dosage: FUJIBETON 2 %

FLYASH %

CEMENT %

Volume After Curing: --- cm³

Final Moisture Content: 22.3 %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D560 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm³)	WEIGHT AFTER THAWING AND BRUSHING (g)
1	893.2	1732.8
2	854.5	1608.3
3	747.6	1336.1
4	710.4	1160.6
5	---	991.4
6		
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated during fifth thawing period

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1720 kg/m³

Sample: Calgary: Bearspaw

Design Optimum Moisture Content: 16.5 %

Sand 24 %, Silt 51 %, Clay 25 %

Initial Dry Density: 1623 kg/m³

Initial Moisture Content: 16.6 %

Initial Volume: 903.2 cm³

Stabilizer Dosage: FUJIBETON 4 %

Volume After Curing: --- cm³

FLYASH %

Final Moisture Content: 19.1 %

CEMENT %

Stabilized Soil Loss: 63 %

Method of Sample Preparation: ASTM D560 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm³)	WEIGHT AFTER THAWING AND BRUSHING (g)
1	901.2	1767.0
2	904.5	1739.3
3	961.0	1823.2
4	779.7	1471.5
5	707.4	1338.4
6	656.3	1222.7
7	568.6	1086.3
8	541.8	994.7
9	491.6	912.1
10	437.4	834.8
11	386.9	737.0
12	361.3	682.1

Remarks: Unconfined compressive strength after durability test determined as 0.82 MPa

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client:	TRANSPORT CANADA	Contract No.:	1 SD 83 - 00026
Project No.:	314 - 1264.02	Design Maximum Dry Density:	1674 kg/m³
Sample:	Calgary: Bearspaw	Design Optimum Moisture Content:	16.3 %
	Sand 24 %, Silt 51 %, Clay 25 %	Initial Dry Density:	1674 kg/m³
		Initial Moisture Content:	16.3 %
		Initial Volume:	938.3 cm³
Stabilizer Dosage: FUJIBETON	4 %	Volume After Curing:	--- cm³
FLYASH	%	Final Moisture Content:	19 %
CEMENT	%	Stabilized Soil Loss:	100 %

Method of Sample Preparation: ASTM D560 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm³)	WEIGHT AFTER THAWING AND BRUSHING (g)
1	929.4	1856.7
2	926.9	1835.4
3	880.9	1791.0
4	903.1	1726.6
5	857.0	1643.5
6	772.4	1556.9
7	740.2	1451.8
8	727.4	1373.7
9	670.8	1302.2
10	662.3	1250.4
11	613.5	1148.7
12	---	1079.8

Remarks: Sample disintegrated during twelth brushing

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1720 kg/m^3

Sample: Calgary: Bearspaw
Sand 24 %, Silt 51 %, Clay 25 %

Design Optimum Moisture Content: 16.5 %

Initial Dry Density: 1627 kg/m^3

Initial Moisture Content: 16.3 %

Initial Volume: 950.4 cm^3

Stabilizer Dosage: FUJIBETON 7 %
FLYASH %
CEMENT %

Volume After Curing: --- cm^3

Final Moisture Content: 20.3 %

Stabilized Soil Loss: 50 %

Method of Sample Preparation: ASTM D560 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm^3)	WEIGHT AFTER THAWING AND BRUSHING (g)
1	942.4	1761.9
2	925.5	1804.6
3	910.6	1774.4
4	912.7	1745.9
5	917.5	1673.9
6	838.3	1552.8
7	802.3	1421.3
8	697.4	1327.8
9	649.5	1217.8
10	616.6	1153.5
11	584.5	1052.2
12	541.7	939.4

Remarks: Unconfined compressive strength after durability test not determined due to sample shape

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA	Contract No.: 1 SD 83 - 00026
Project No.: 314 - 1264.02	Design Maximum Dry Density: 1675 kg/m^3
Sample: Calgary: Bearspaw	Design Optimum Moisture Content: 16.2 %
Sand 24 %, Silt 51 %, Clay 25 %	Initial Dry Density: 1667 kg/m^3
	Initial Moisture Content: 16.2 %
	Initial Volume: 932.3 cm^3
Stabilizer Dosage: FUJIBETON 7 %	Volume After Curing: --- cm^3
FLYASH %	Final Moisture Content: 18.5 %
CEMENT %	Stabilized Soil Loss: 22 %

Method of Sample Preparation: ASTM D560 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm^3)	WEIGHT AFTER THAWING AND BRUSHING (g)
1	932.2	1837.0
2	918.4	1844.3
3	920.6	1852.5
4	918.6	1821.4
5	921.0	1814.3
6	898.5	1788.8
7	907.9	1723.5
8	880.6	1706.0
9	877.0	1657.9
10	821.0	1608.1
11	790.4	1537.9
12	829.4	1485.6

Remarks: Unconfined compressive strength after durability test determined as 1.1 MPa

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1715 kg/m³

Sample: Calgary: Bearspaw

Sand 24 %, Silt 51 %, Clay 25 %

Design Optimum Moisture Content: 16.5 %

Initial Dry Density: 1624 kg/m³

Initial Moisture Content: 16.1 %

Initial Volume: 933.1 cm³

Stabilizer Dosage: FUJIBETON 9 %

FLYASH %

CEMENT %

Volume After Curing: --- cm³

Final Moisture Content: 18.4 %

Stabilized Soil Loss: 48 %

Method of Sample Preparation: ASTM D560 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm³)	WEIGHT AFTER THAWING AND BRUSHING (g)
1	920.1	1777.3
2	934.1	1810.1
3	909.2	1794.1
4	894.6	1714.1
5	860.7	1622.0
6	814.4	1531.3
7	745.2	1360.7
8	700.7	1269.7
9	611.9	1173.2
10	616.7	1104.1
11	548.0	1028.9
12	524.2	966.9

Remarks: Unconfined compressive strength after durability test determined as 4.0 MPa

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 · 00026

Project No.: 314 · 1264.02

Design Maximum Dry Density: 1716 kg/m^3

Sample: Calgary: Bearspaw
Sand 24 %, Silt 51 %, Clay 25 %

Design Optimum Moisture Content: 17.7 %

Initial Dry Density: 1667 kg/m^3

Initial Moisture Content: 15.8 %

Initial Volume: 936.1 cm^3

Stabilizer Dosage: FUJIBETON 9 %
FLYASH %
CEMENT %

Volume After Curing: --- cm^3

Final Moisture Content: 18.0 %

Stabilized Soil Loss: 13 %

Method of Sample Preparation: ASTM D560 · 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm^3)	WEIGHT AFTER THAWING AND BRUSHING (g)
1	929.4	1840.8
2	935.1	1861.2
3	927.4	1869.2
4	917.6	1851.7
5	911.5	1843.3
6	923.4	1836.5
7	927.6	1827.6
8	933.3	1812.5
9	915.9	1753.1
10	926.5	1759.5
11	891.6	1702.5
12	874.0	1652.2

Remarks: Unconfined compressive strength after durability test determined as 2.6 MPa

EBA Engineering Consultants Ltd.

eba

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1720 kg/m³

Sample: Calgary: Bearspaw

Sand 24 %, Silt 51 %, Clay 25 %

Design Optimum Moisture Content: 16.0 %

Initial Dry Density: 1620 kg/m³

Initial Moisture Content: 16.1 %

Initial Volume: 953.0 cm³

Stabilizer Dosage: FUJIBETON 12 %

FLYASH %

CEMENT %

Volume After Curing: --- cm³

Final Moisture Content: 18.6 %

Stabilized Soil Loss: 30 %

Method of Sample Preparation: ASTM D560 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm³)	WEIGHT AFTER THAWING AND BRUSHING (g)
1	963.9	1869.2
2	940.3	1819.5
3	929.6	1821.6
4	911.6	1804.2
5	925.7	1781.1
6	955.5	1637.0
7	921.0	1577.8
8	879.1	1476.5
9	887.4	1430.3
10	826.3	1327.6
11	746.3	1343.6
12	726.5	1301.6

Remarks: Unconfined compressive strength after durability determined as 0.85 MPa

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Project No.: 314 - 1264.02

Sample: Calgary: Bearspaw

Sand 24 %, Silt 51 %, Clay 25 %

Stabilizer Dosage: FUJIBETON 12 %

FLYASH %

CEMENT %

Contract No.: 1 SD 83 - 00026

Design Maximum Dry Density: 1690 kg/m^3

Design Optimum Moisture Content: 16.5 %

Initial Dry Density: 1686 kg/m^3

Initial Moisture Content: 16.2 %

Initial Volume: 946.8 cm^3

Volume After Curing: --- cm^3

Final Moisture Content: 18.2 %

Stabilized Soil Loss: 4.0 %

Method of Sample Preparation: ASTM D560 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm^3)	WEIGHT AFTER THAWING AND BRUSHING (g)
1	943.2	1853.1
2	932.1	1882.4
3	926.4	1884.1
4	917.1	1886.1
5	916.3	1886.4
6	935.5	1884.5
7	939.2	1886.9
8	930.0	1893.7
9	948.3	1884.6
10	925.5	1889.6
11	917.1	1881.1
12	938.2	1859.6

Remarks: Unconfined compressive strength after durability test determined as 3.9 MPa

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1722 kg/m^3

Sample: Calgary: Bearspaw

Sand 24 %, Silt 51 %, Clay 25 %

Design Optimum Moisture Content: 16.7 %

Initial Dry Density: 1634 kg/m^3

Initial Moisture Content: 16.3 %

Initial Volume: 929.0 cm^3

Volume After Curing: --- cm^3

Final Moisture Content: --- %

Stabilized Soil Loss: 100 %

Stabilizer Dosage:

FUJIBETON ____ %

FLYASH 2 %

CEMENT ____ %

Method of Sample Preparation: ASTM D560 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm^3)	WEIGHT AFTER THAWING AND BRUSHING (g)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated during handling after first thaw period

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No: 314 - 1264.02

Design Maximum Dry Density: 1710 kg/m³

Sample: Calgary: Bearspaw

Sand 24 %, Silt 51 %, Clay 25 %

Design Optimum Moisture Content: 15.7 %

Initial Dry Density: 1676 kg/m³

Initial Moisture Content: 16.6 %

Initial Volume: 932.9 cm³

Stabilizer Dosage: FUJIBETON ____ %

FLYASH 2 %

CEMENT ____ %

Volume After Curing: --- cm³

Final Moisture Content: --- %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D560 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm³)	WEIGHT AFTER THAWING AND BRUSHING (g)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated after first thawing period during brushing

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1725 kg/m³

Sample: Calgary: Bearspaw

Sand 24 %, Silt 51 %, Clay 25 %

Design Optimum Moisture Content: 15.0 %

Initial Dry Density: 1628.4 kg/m³

Initial Moisture Content: 15.2 %

Initial Volume: 927.8 cm³

Stabilizer Dosage: FUJIBETON %

FLYASH 6 %

CEMENT %

Volume After Curing: --- cm³

Final Moisture Content: --- %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D560 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm³)	WEIGHT AFTER THAWING AND BRUSHING (g)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated during handling after first thaw period

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1697 kg/m^3

Sample: Calgary: Bearspaw

Sand 24 %, Silt 51 %, Clay 25 %

Design Optimum Moisture Content: 16.0 %

Initial Dry Density: 1670 kg/m^3

Initial Moisture Content: 15.9 %

Initial Volume: 944.8 cm^3

Stabilizer Dosage: FUJIBETON %

Volume After Curing: --- cm^3

FLYASH 6 %

Final Moisture Content: --- %

CEMENT %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D560 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm^3)	WEIGHT AFTER THAWING AND BRUSHING (g)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated after first thawing period during brushing

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1752 kg/m^3

Sample: Calgary: Bearspaw

Design Optimum Moisture Content: 15.6 %

Sand 24 %, Silt 51 %, Clay 25 %

Initial Dry Density: 1649 kg/m^3

Initial Moisture Content: 16.1 %

Initial Volume: 937.2 cm^3

Stabilizer Dosage: FUJIBETON %

Volume After Curing: --- cm^3

FLYASH 10 %

Final Moisture Content: --- %

CEMENT %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D560 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm^3)	WEIGHT AFTER THAWING AND BRUSHING (g)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated during handling after first thaw period

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1720 kg/m3

Sample: Calgary: Bearspaw

Sand 24 %, Silt 51 %, Clay 25 %

Design Optimum Moisture Content: 15.0 %

Initial Dry Density: 1661 kg/m3

Initial Moisture Content: 17.2 %

Initial Volume: 938.7 cm3

Stabilizer Dosage: FUJIBETON ____ %

FLYASH 10 %

CEMENT ____ %

Volume After Curing: --- cm3

Final Moisture Content: --- %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D560 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm3)	WEIGHT AFTER THAWING AND BRUSHING (g)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated after first thawing period during brushing

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1728 kg/m³

Sample: Calgary: Bearspaw

Sand 24 %, Silt 51 %, Clay 25 %

Design Optimum Moisture Content: 15.5 %

Initial Dry Density: 1624 kg/m³

Initial Moisture Content: 15.8 %

Initial Volume: 932.6 cm³

Volume After Curing: --- cm³

Final Moisture Content: --- %

Stabilized Soil Loss: 100 %

Stabilizer Dosage: FUJIBETON ___ %

FLYASH 13 %

CEMENT ___ %

Method of Sample Preparation: ASTM D560 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm³)	WEIGHT AFTER THAWING AND BRUSHING (g)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated during handling after first thaw period

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1735 kg/m^3

Sample: Calgary: Bearspaw

Sand 24 %, Silt 51 %, Clay 25 %

Design Optimum Moisture Content: 15.5 %

Initial Dry Density: 1695 kg/m^3

Initial Moisture Content: 15.2 %

Initial Volume: 928.3 cm^3

Stabilizer Dosage: FUJIBETON %

FLYASH 13 %

CEMENT %

Volume After Curing: --- cm^3

Final Moisture Content: --- %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D560 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm^3)	WEIGHT AFTER THAWING AND BRUSHING (g)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated after first thawing period during brushing

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1725 kg/m³

Sample: Calgary: Bearspaw

Sand 24 %, Silt 51 %, Clay 25 %

Design Optimum Moisture Content: 15.8 %

Initial Dry Density: 1628 kg/m³

Initial Moisture Content: 16.2 %

Initial Volume: 919.3 cm³

Stabilizer Dosage: FUJIBETON ___ %

Volume After Curing: --- cm³

FLYASH 7 %

Final Moisture Content: 19.2 %

CEMENT 3 %

Stabilized Soil Loss: 80 %

Method of Sample Preparation: ASTM D560 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm³)	WEIGHT AFTER THAWING AND BRUSHING (g)
1	918.9	1775.3
2	902.0	1640.2
3	754.6	1418.3
4	642.3	1223.4
5	587.8	1057.6
6	547.0	941.9
7	403.0	780.0
8	386.9	679.3
9	335.6	609.9
10	297.9	508.7
11	266.4	452.0
12	211.7	359.0

Remarks: Unconfined compression strength after durability test not determined due to size of sample

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client:	TRANSPORT CANADA	Contract No.:	1 SD 83 - 00026
Project No.:	314 - 1264 02	Design Maximum Dry Density:	1658 kg/m³
Sample:	Calgary: Bearspaw	Design Optimum Moisture Content:	16.4 %
	Sand 24 %, Silt 51 %, Clay 25 %	Initial Dry Density:	1663 kg/m³
		Initial Moisture Content:	16.2 %
		Initial Volume:	948.6 cm³
Stabilizer Dosage:	FUJIBETON ___ %	Volume After Curing:	--- cm³
	FLYASH 7 %	Final Moisture Content:	--- %
	CEMENT 3 %	Stabilized Soil Loss:	100 %

Method of Sample Preparation: ASTM D560 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm³)	WEIGHT AFTER THAWING AND BRUSHING (g)
1	949.2	1804.8
2	905.7	1767.7
3	846.1	1640.1
4	743.4	1499.7
5	616.2	1361.9
6		
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated during sixth thawing period

ATTERBERG LIMITS TEST DATA

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264. 02

SAMPLE	STABILIZER DOSAGE (%)			REACTION TIME (hours)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX
	FUJIBETON	FLYASH	CEMENT				
Calgary: Bearspaw II	0	0	0	–	18.9	26.5	7.6
	–	5	2	1	19.6	26.6	7.0
	–	5	2	8	–	–	Non Plastic
	–	7	2	1	22.6	29.4	6.8
	–	7	2	8	–	–	Non Plastic
	–	10	2	1	21.8	28.4	6.6
	–	10	2	8	–	–	Non Plastic
	–	5	3	1	23.3	29.6	6.3
	–	5	3	8	–	–	Non Plastic
	–	9	3	1	20.5	31.8	11.3
	–	9	3	8	–	–	Non Plastic
	–	5	4	1	25.2	32.4	7.2
	–	5	4	8	–	–	Non Plastic
	–	7	4	1	24.9	31.3	6.4
	–	7	4	8	–	–	Non Plastic
	–	9	4	1	22.6	29.3	6.7
	–	9	4	8	–	–	Non Plastic
	–	7	3	0.25 (mix.)	20.3	30.2	9.9
	–	7	3	1	23.5	30.5	7.0
	–	7	3	24	–	–	Non Plastic
	–	16	–	0.25 (mix.)	18.1	26.6	8.5
	–	16	–	1	18.5	24.9	6.4
	–	16	–	24	31.7	34.2	2.5

PAGE 1 OF 1

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1SD83 - 00026

Project No.: 314 - 1264.02

Stabilizer Dosage: FUJIBETON ____ %

Sample: Calgary: Bearspaw II

FLYASH 5 %

Sand 20%, Silt 56%, Clay 24%

CEMENT 2 %

TEST DATA:

1) Method of Sample Preparation: ASTM D 558 - 57

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	2.9	1644
2	5.5	1663
3	8.2	1642
4	23.7	1526
5	14.1	1704

Design Field Optimum Moisture Content: 13.5 %

Design Field Maximum Dry Density: 1730 kg/m³

2) Method of Sample Preparation: ASTM D558 - 57, but using 19 blows to compact each layer instead of 25 blows

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1		
2		
3		
4		
5		

Design Field Optimum Moisture Content: ____ %

Design Field Maximum Dry Density: ____ kg/m³

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

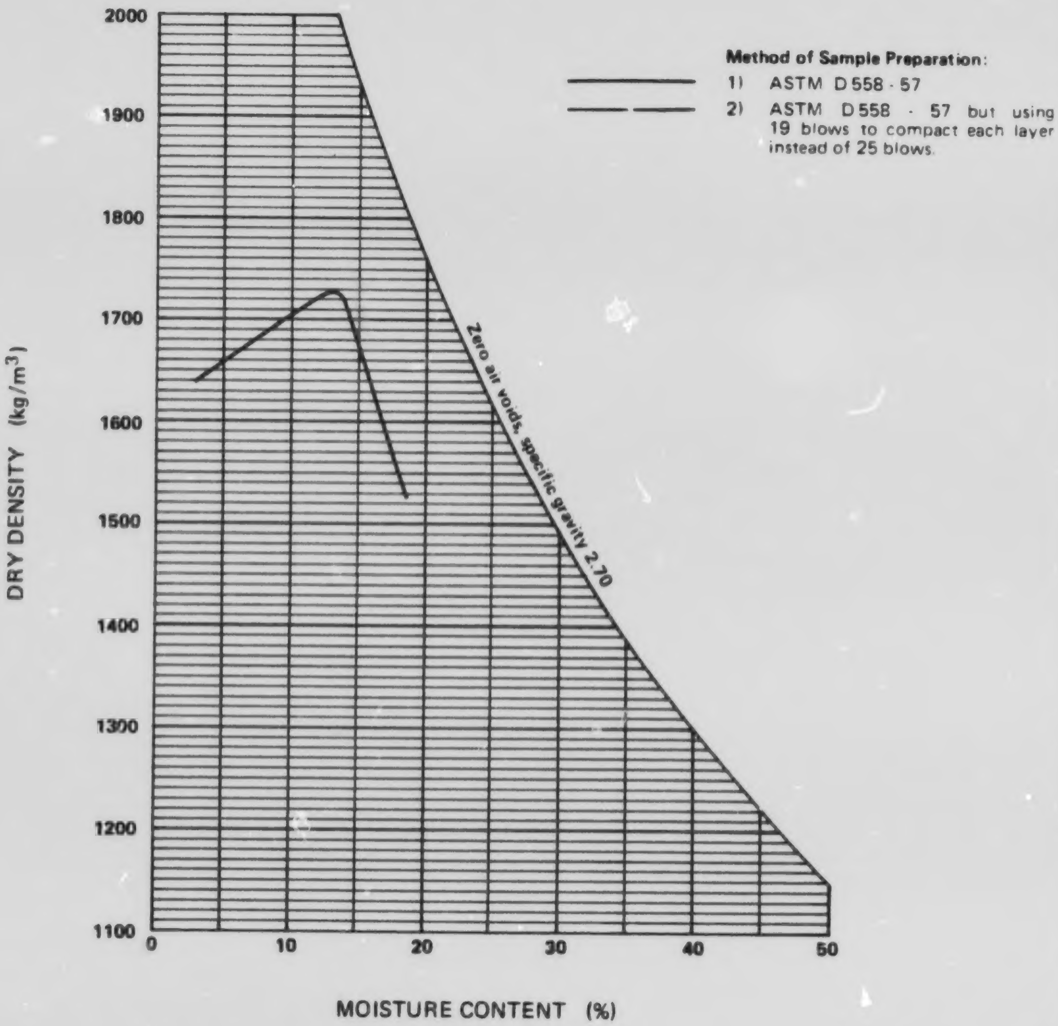
Stabilizer Dosage: FUJIBETON ____ %

FLYASH 5 %

CEMENT 2 %

Sample: Calgary: Bearspaw II

Sand 20 %, Silt 56 %, Clay 24 %



DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA
Contract No.: 1SD83 - 00026

Project No.: 314 - 1264.02
Stabilizer Dosage: FUJIBETON ____ %

Sample: Calgary: Bearspaw II
FLYASH 7 %

Sand 20%, Silt 56%, Clay 24%
CEMENT 2 %

TEST DATA:

1) Method of Sample Preparation: ASTM D 558 - 57

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	4.2	1634
2	8.7	1648
3	13.6	1729
4	18.6	1671
5	23.6	1518

Design Field Optimum Moisture Content: 13.7 %

Design Field Maximum Dry Density: 1738 kg/m³

2) Method of Sample Preparation: ASTM D558 - 57, but using 19 blows to compact each layer instead of 25 blows

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1		
2		
3		
4		
5		

Design Field Optimum Moisture Content: ____ %

Design Field Maximum Dry Density: ____ kg/m³

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1[illegible]64.02

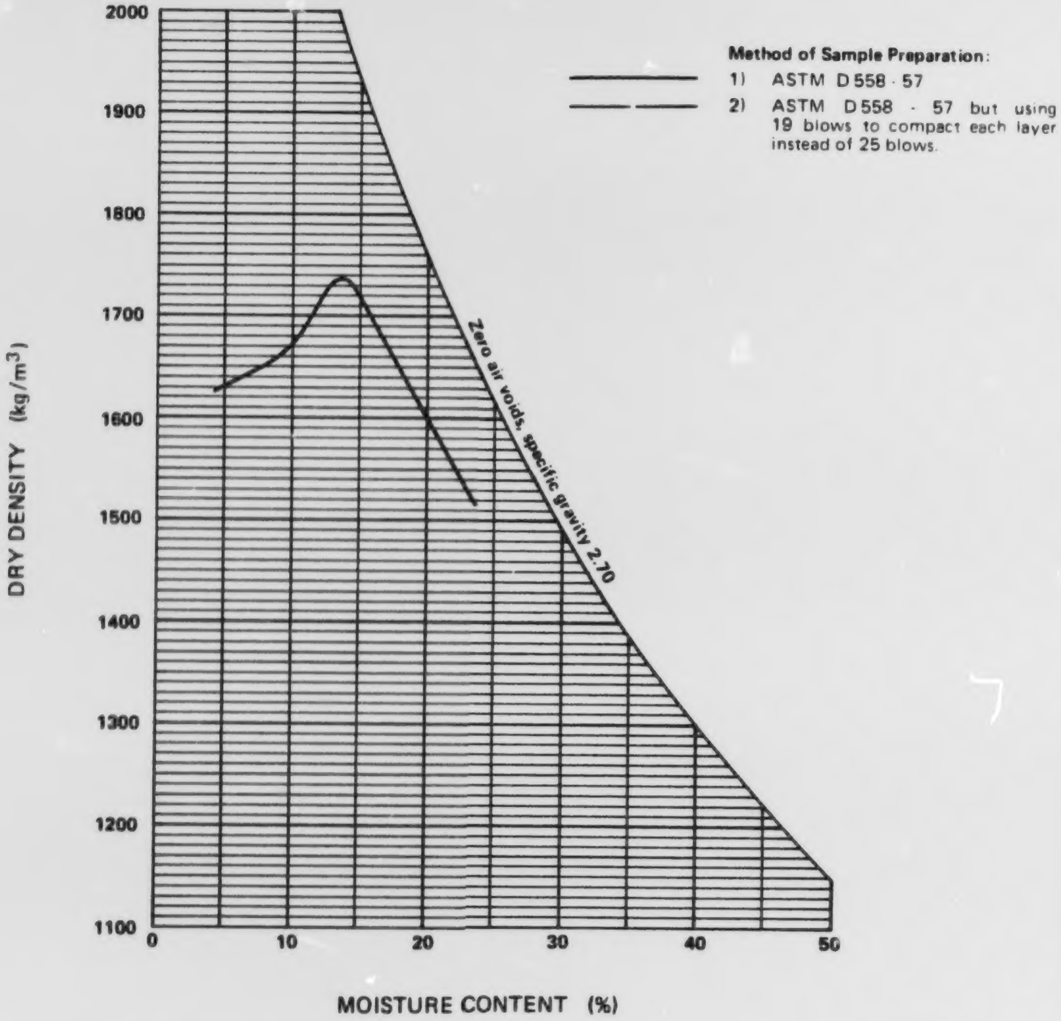
Stabilizer Dosage: FUJIBETON ____ %

FLYASH 7 %

CEMENT 2 %

Sample: Calgary: Bearspaw II

Sand 20 %, Silt 56 %, Clay 24 %



SHEET 2 OF 2

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA Contract No.: 1SD83 - 00026

Project No.: 314 - 1264.02 Stabilizer Dosage: FUJIBETON ______ %

Sample: Calgary: Bearspaw II FLYASH 10 %

Sand 20%, Silt 56%, Clay 24% CEMENT 2 %

TEST DATA:

1) Method of Sample Preparation: ASTM D 558 - 57

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	4.7	1645
2	8.7	1654
3	13.9	1693
4	18.4	1657
5	23.8	1508

Design Field Optimum Moisture Content: 14.0 %

Design Field Maximum Dry Density: 1705 kg/m³

2) Method of Sample Preparation: ASTM D558 - 57, but using 19 blows to compact each layer instead of 25 blows

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1		
2		
3		
4		
5		

Design Field Optimum Moisture Content: ______ %

Design Field Maximum Dry Density: ______ kg/m³

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

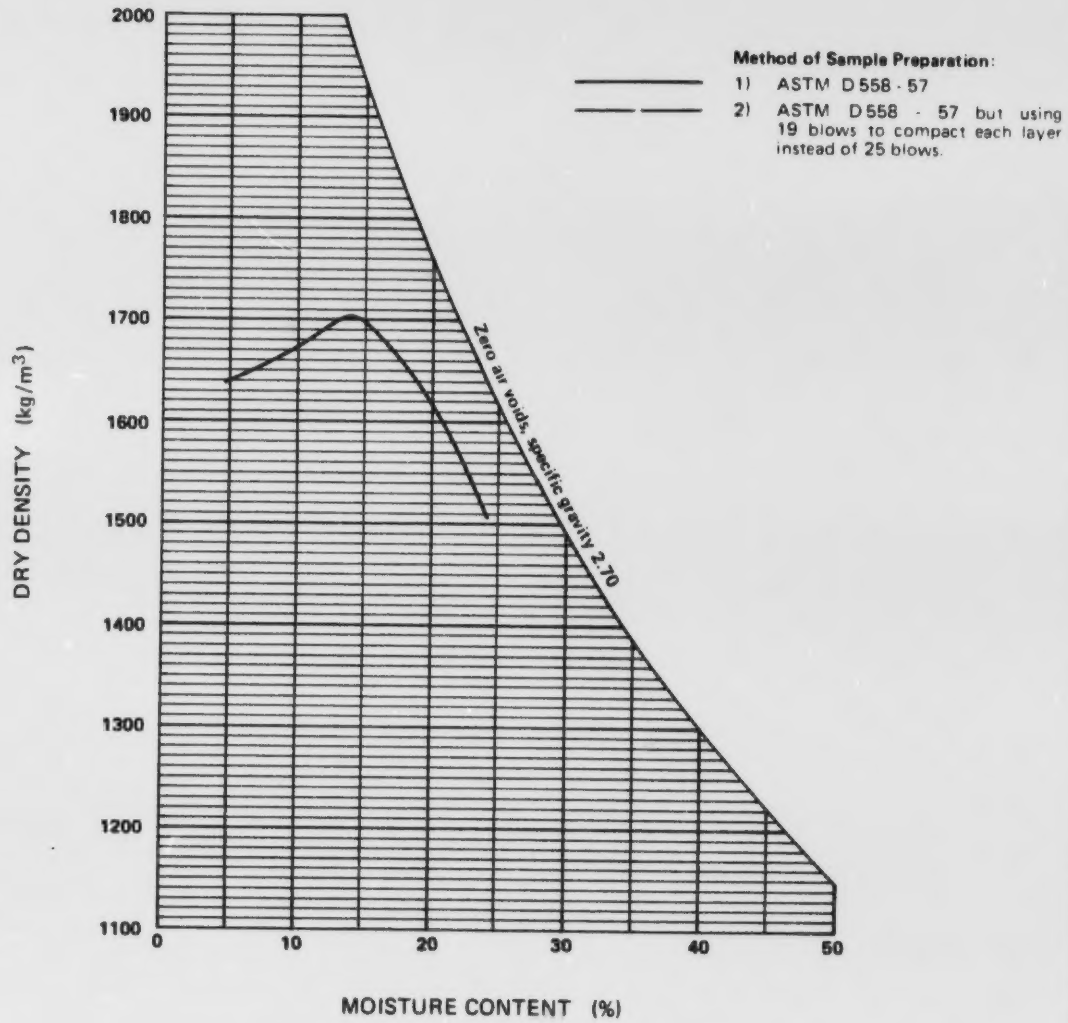
Stabilizer Dosage: FUJIBETON ______ %

FLYASH 10 %

CEMENT 2 %

Sample: Calgary: Bearspaw II

Sand 20 %, Silt 56 %, Clay 24 %



SHEET 2 OF 2

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1SD83 - 00026

Project No.: 314 - 1264.02

Stabilizer Dosage: FUJIBETON ______ %

FLYASH 5 %

CEMENT 3 %

Sample: Calgary: Bearspaw II

Sand 20%, Silt 56%, Clay 24%

TEST DATA:

1) Method of Sample Preparation: ASTM D 558 - 57

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	4.5	1654
2	9.2	1636
3	13.8	1719
4	18.4	1676
5	22.6	1533

Design Field Optimum Moisture Content: 14.0 %

Design Field Maximum Dry Density: 1725 kg/m³

2) Method of Sample Preparation: ASTM D558 - 57, but using 19 blows to compact each layer instead of 25 blows

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1		
2		
3		
4		
5		

Design Field Optimum Moisture Content: ______ %

Design Field Maximum Dry Density: ______ kg/m³

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

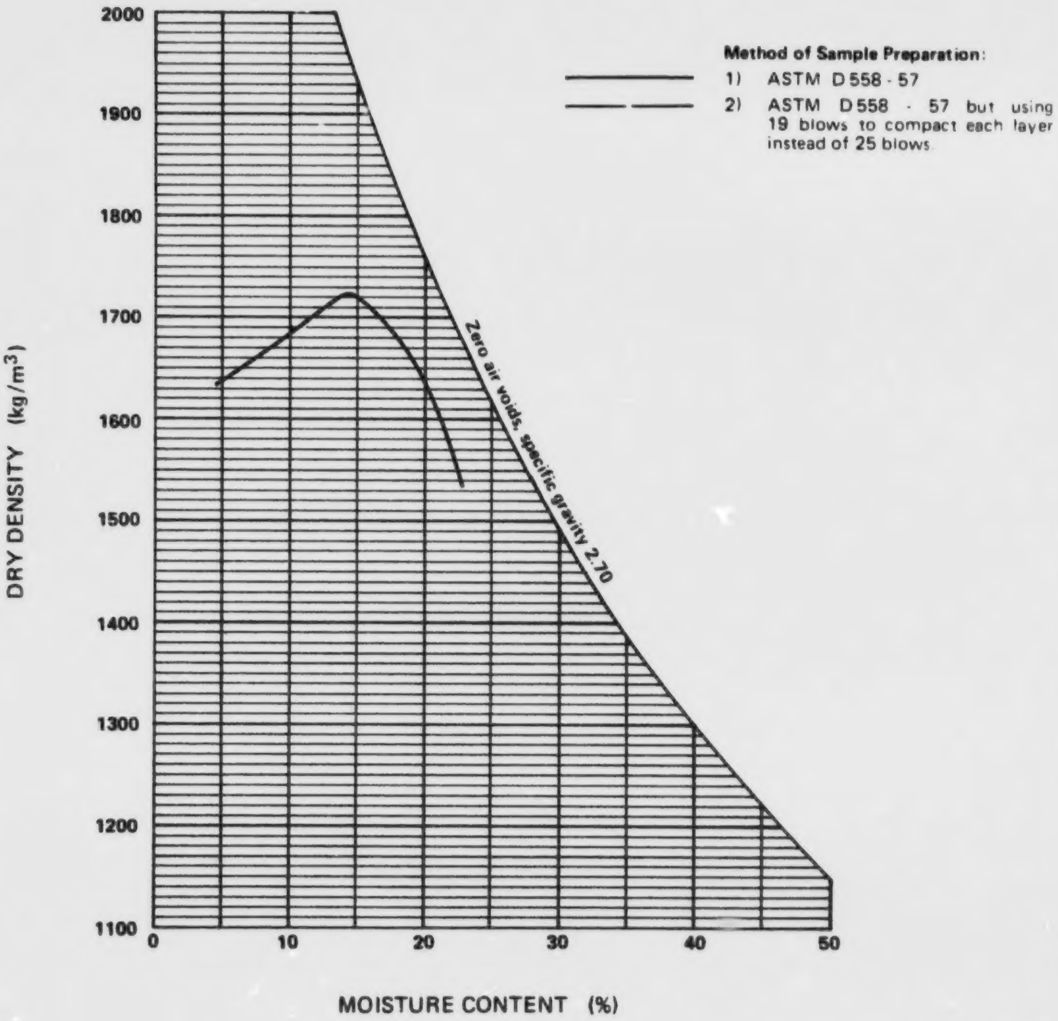
Stabilizer Dosage: FUJIBETON ______ %

FLYASH 5 %

CEMENT 3 %

Sample: Calgary: Bearspaw II

Sand 20 %, Silt 56 %, Clay 24 %



SHEET 2 OF 2

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA Contract No.: 1SD83 - 00026

Project No.: 314 - 1264.02 Stabilizer Dosage: FUJIBETON ___ %

Sample: Calgary: Bearspaw II FLYASH 9 %

Sand 20%, Silt 56%, Clay 24% CEMENT 3 %

TEST DATA:

1) Method of Sample Preparation: ASTM D 558 - 57

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	4.8	1649
2	8.5	1640
3	13.3	1712
4	17.7	1658
5	23.1	1527

Design Field Optimum Moisture Content: 13.0 %

Design Field Maximum Dry Density: 1720 kg/m³

2) Method of Sample Preparation: ASTM D558 - 57, but using 19 blows to compact each layer instead of 25 blows

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1		
2		
3		
4		
5		

Design Field Optimum Moisture Content: ___ %

Design Field Maximum Dry Density: ___ kg/m³

SHEET 1 OF 2

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

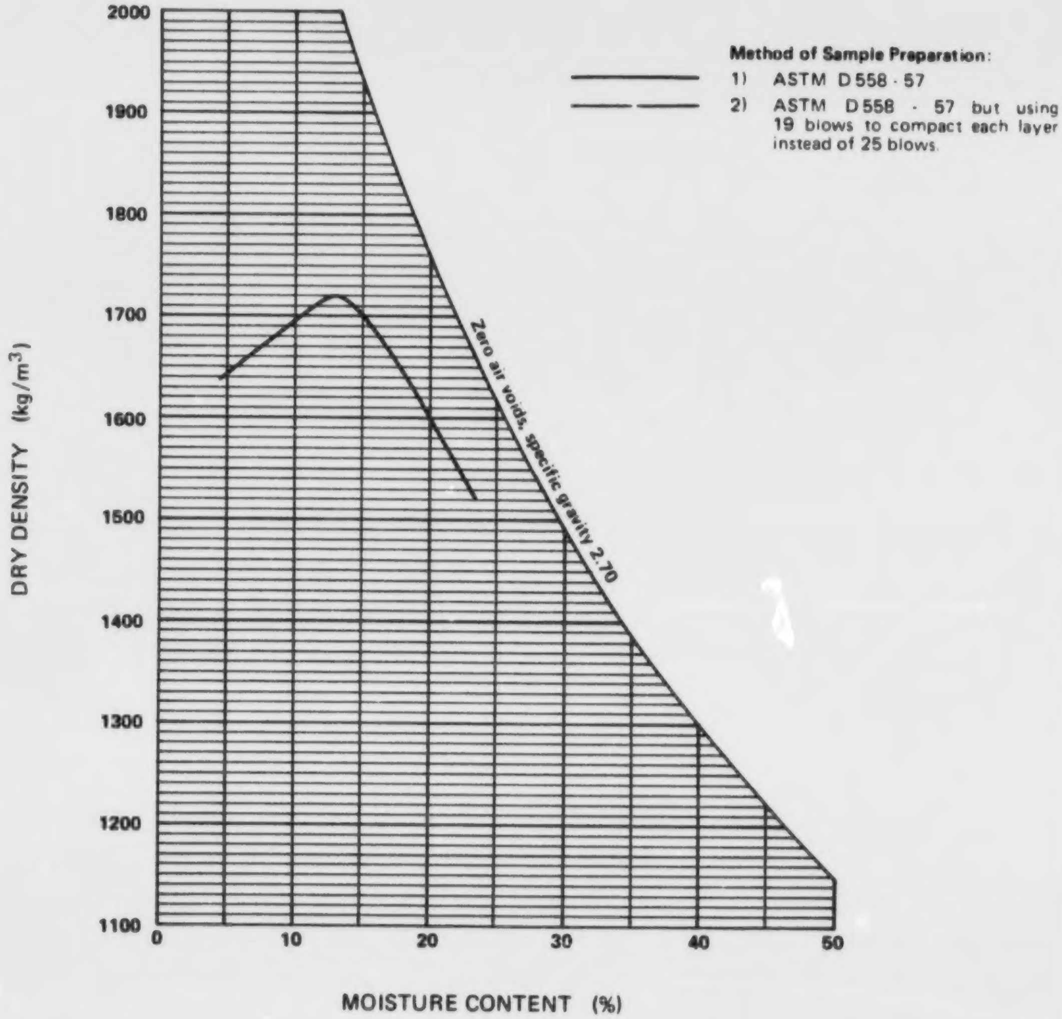
Stabilizer Dosage: FUJIBETON ____ %

Sample: Calgary: Bearspaw II

Sand 20 %, Silt 56 %, Clay 24 %

FLYASH 9 %

CEMENT 3 %



SHEET 2 OF 2

DRY DENSITY/MOISTURE CONTENT
RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1SD83 - 00026

Project No.: 314 - 1264.02

Stabilizer Dosage: FUJIBETON ____ %

FLYASH 5 %

CEMENT 4 %

Sample: Calgary: Bearspaw II

Sand 20%, Silt 56%, Clay 24%

TEST DATA:

1) Method of Sample Preparation: ASTM D 558 - 57

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	5.1	1629
2	9.1	1646
3	13.9	1720
4	19.6	1641
5	25.0	1502

Design Field Optimum Moisture Content: 13.5 %

Design Field Maximum Dry Density: 1722 kg/m³

2) Method of Sample Preparation: ASTM D558 - 57, but using 19 blows to compact each layer instead of 25 blows

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1		
2		
3		
4		
5		

Design Field Optimum Moisture Content: ____ %

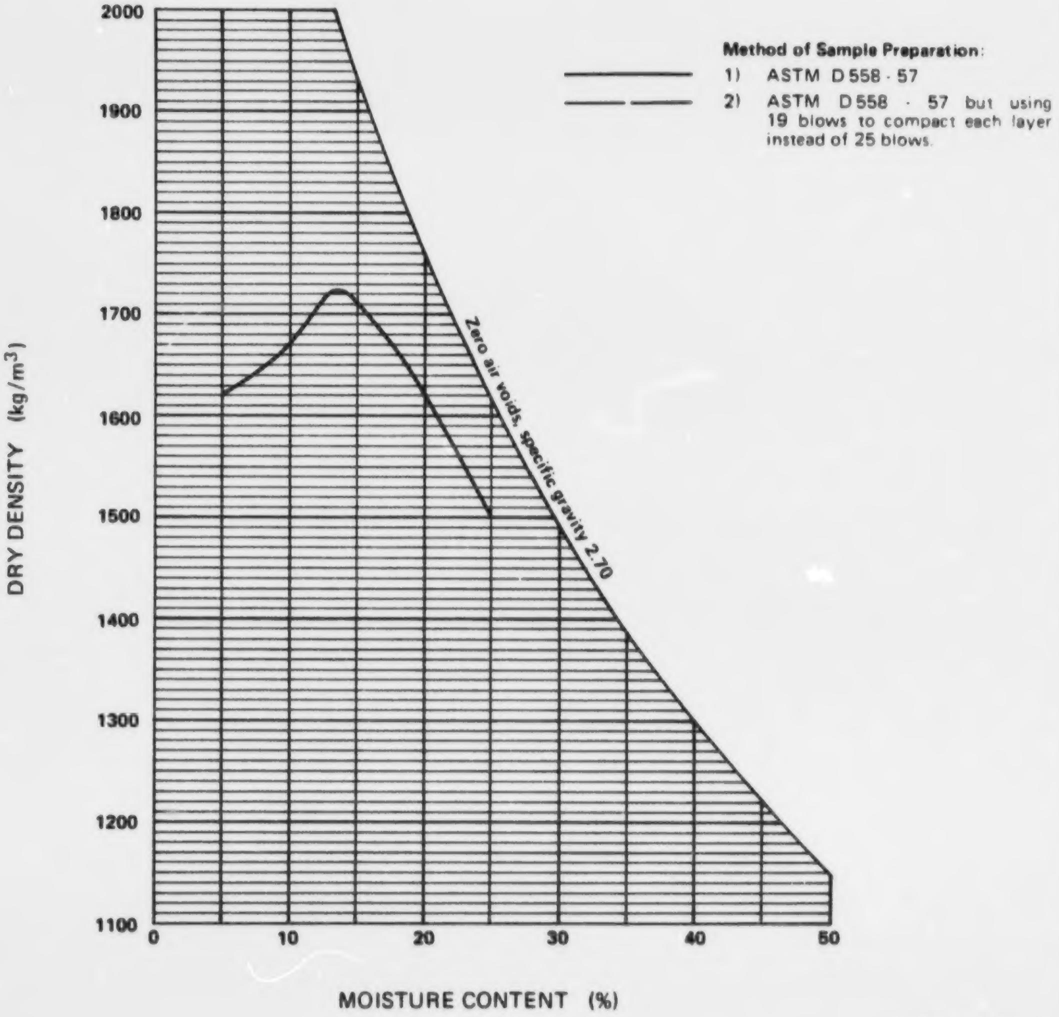
Design Field Maximum Dry Density: ____ kg/m³

SHEET 1 OF 2

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA	Contract No.: 1 SD 83 - 00026
Project No.: 314 - 1264.02	Stabilizer Dosage: FUJIBETON ______ %
Sample: Calgary: Bearspaw II	FLYASH 5 %
Sand 20 %, Silt 56 %, Clay 24 %	CEMENT 4 %



SHEET 2 OF 2

EBA Engineering Consultants Ltd.

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1SD83 - 00026

Project No.: 314 - 1264.02

Stabilizer Dosage: FUJIBETON ____ %

FLYASH 7 %

CEMENT 4 %

Sample: Calgary: Bearspaw II

Sand 20%, Silt 56%, Clay 24%

TEST DATA:

1) Method of Sample Preparation: ASTM D 558 - 57

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	5.0	1649
2	10.1	1656
3	14.5	1718
4	18.3	1672
5	24.3	1520

Design Field Optimum Moisture Content: 13.0 %

Design Field Maximum Dry Density: 1742 kg/m³

2) Method of Sample Preparation: ASTM D558 - 57, but using 19 blows to compact each layer instead of 25 blows

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1		
2		
3		
4		
5		

Design Field Optimum Moisture Content: ____ %

Design Field Maximum Dry Density: ____ kg/m³

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

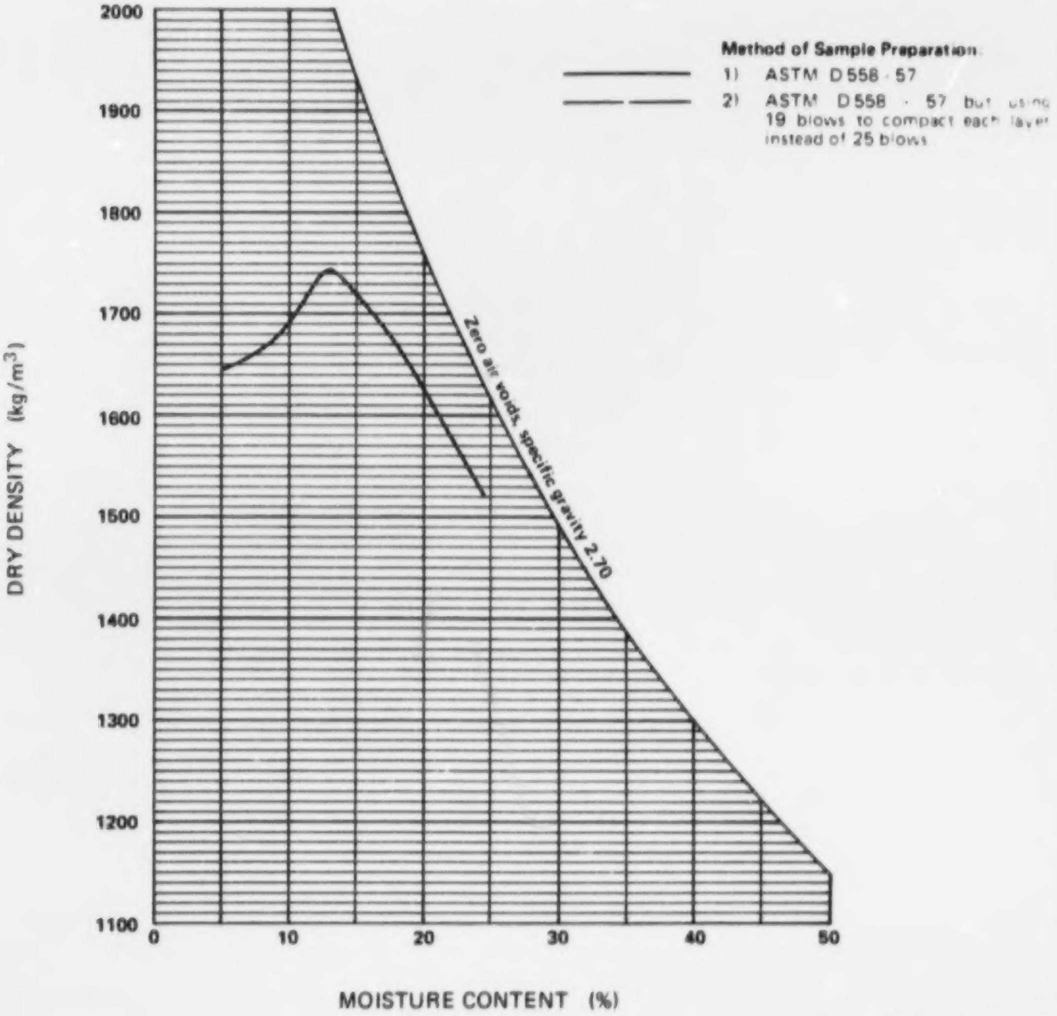
Stabilizer Dosage: FUJIBETON ______ %

FLYASH 7 %

CEMENT 4 %

Sample: Calgary: Bearspaw II

Sand 20 %, Silt 56 %, Clay 24 %



SHEET 2 OF 2

EBA Engineering Consultants Ltd.

eba

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1SD83 - 00026

Project No.: 314 - 1264.02

Stabilizer Dosage: FUJIBETON ____ %

Sample: Calgary: Bearspaw II

FLYASH 9 %

Sand 20%, Silt 56%, Clay 24%

CEMENT 4 %

TEST DATA:

1) Method of Sample Preparation: ASTM D 558 - 57

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	4.8	1652
2	8.7	1651
3	17.2	1659
4	18.7	1660
5	23.6	1515

Design Field Optimum Moisture Content: 14.5 %

Design Field Maximum Dry Density: 1710 kg/m³

2) Method of Sample Preparation: ASTM D558 - 57, but using 19 blows to compact each layer instead of 25 blows

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1		
2		
3		
4		
5		

Design Field Optimum Moisture Content: ____ %

Design Field Maximum Dry Density: ____ kg/m³

SHEET 1 OF 2

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

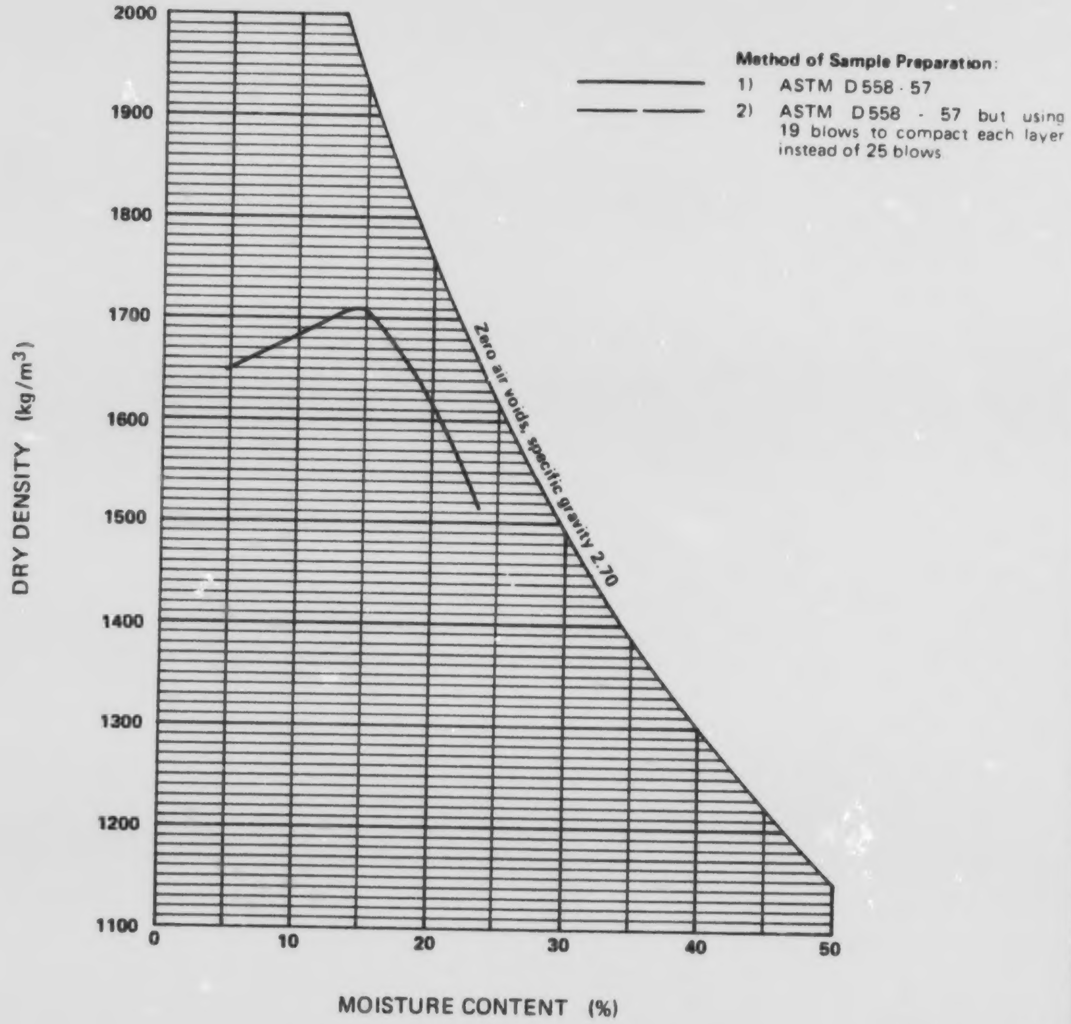
Stabilizer Dosage: FUJIBETON ____ %

FLYASH 9 %

CEMENT 4 %

Sample: Calgary: Bearspaw II

Sand 20 %, Silt 56 %, Clay 24 %



SHEET 2 OF 2

CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA — Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Calgary: Bearspaw II — Initial Dry Density: 1666 kg/m^3

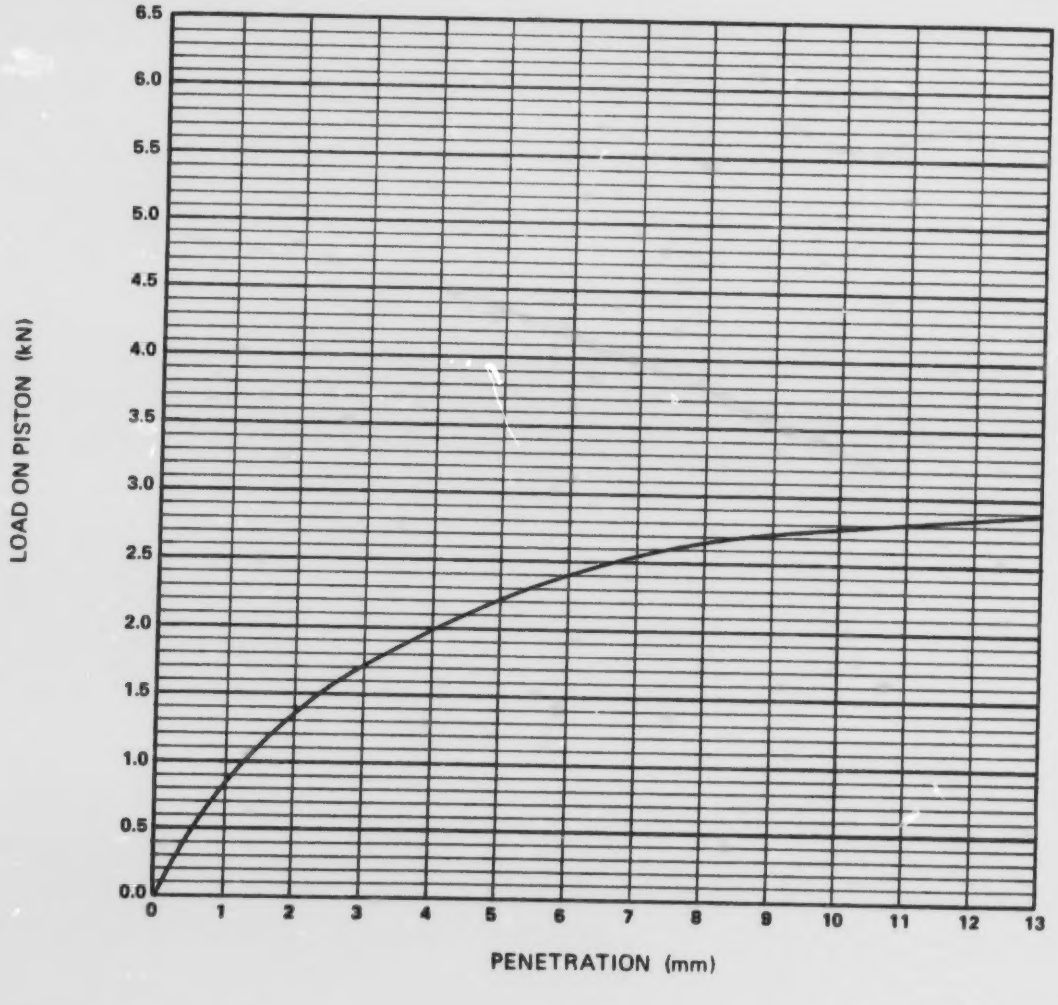
Sand 20% , Silt 56% , Clay 24% — Initial Moisture Content: 12.0 %

Stabilizer Dosage: FUJIBETON ____ % — Final Moisture Content: 24.9 %

FLYASH 5 % — California Bearing Ratio: 2.5 mm 12 %

CEMENT 2 % — 5.0 mm 11 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 100% of standard compactive effort, then cured at 20° C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Calgary: Bearspaw II

Sand 20% , Silt 56% , Clay 24%

Initial Dry Density: 1657 kg/m^3

Initial Moisture Content: 13.3 %

Stabilizer Dosage: FUJIBETON ______ %

FLYASH 7 %

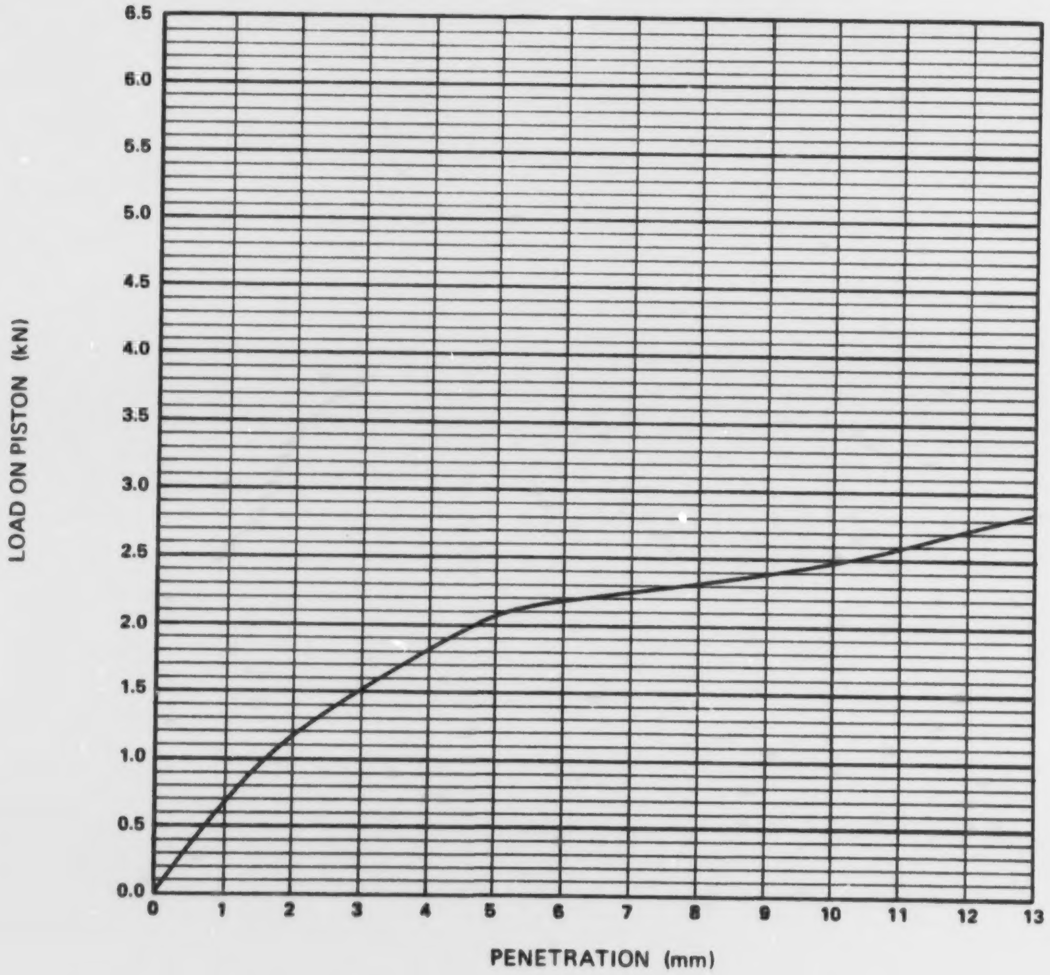
CEMENT 2 %

Final Moisture Content: 25.4 %

California Bearing Ratio: 2.5 mm 10 %

5.0 mm 11 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 100% of standard compactive effort, then cured at 20° C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Calgary: Bearspaw II

Sand 20%, Silt 56%, Clay 24%

Initial Dry Density: 1635 kg/m^3

Initial Moisture Content: 12.9 %

Stabilizer Dosage: FUJIBETON %

FLYASH 10 %

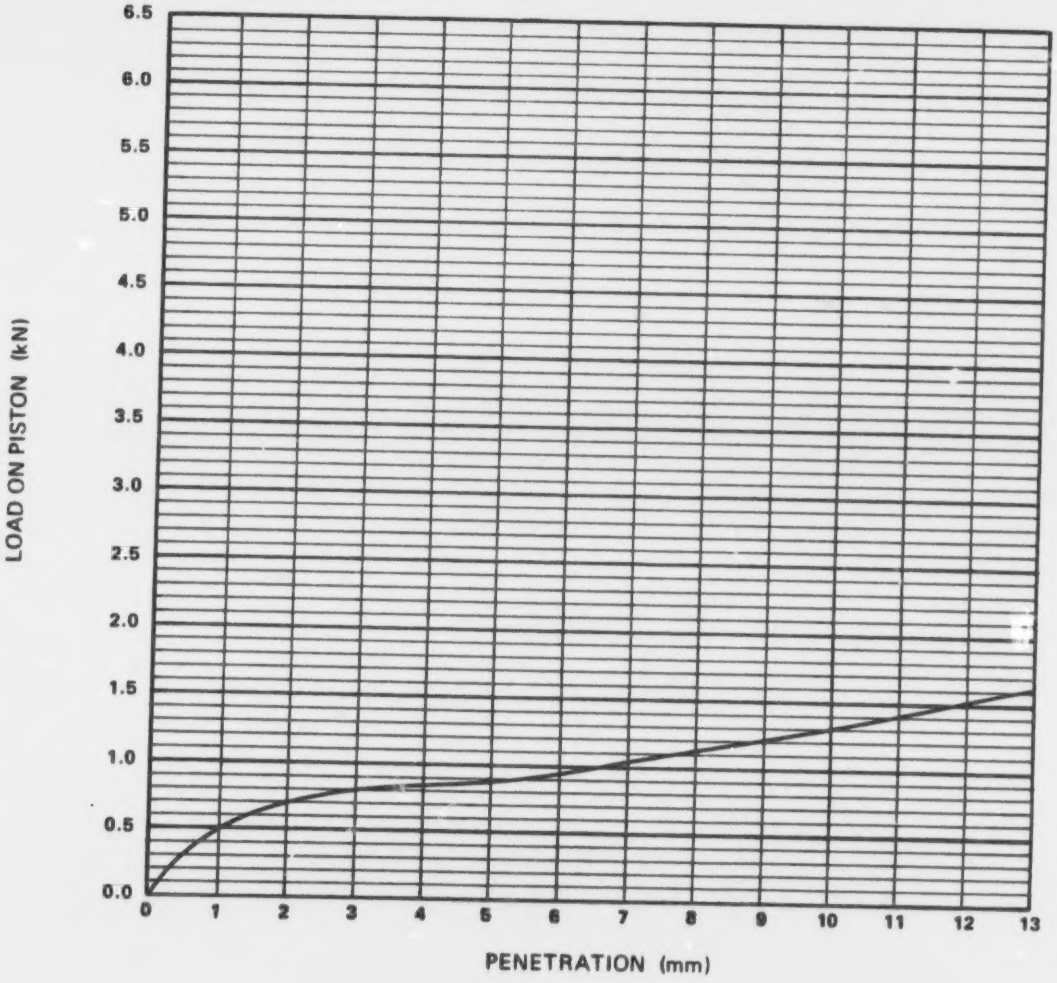
CEMENT 2 %

Final Moisture Content: 16.1 %

California Bearing Ratio: 2.5 mm 5.7 %

5.0 mm 4.2 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 100% of standard compactive effort, then cured at 20° C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Calgary: Bearspaw II

Sand 20% , Silt 56% , Clay 24%

Initial Dry Density: 1668 kg/m^3

Initial Moisture Content: 12.0 %

Stabilizer Dosage: FUJIBETON %

FLYASH 5 %

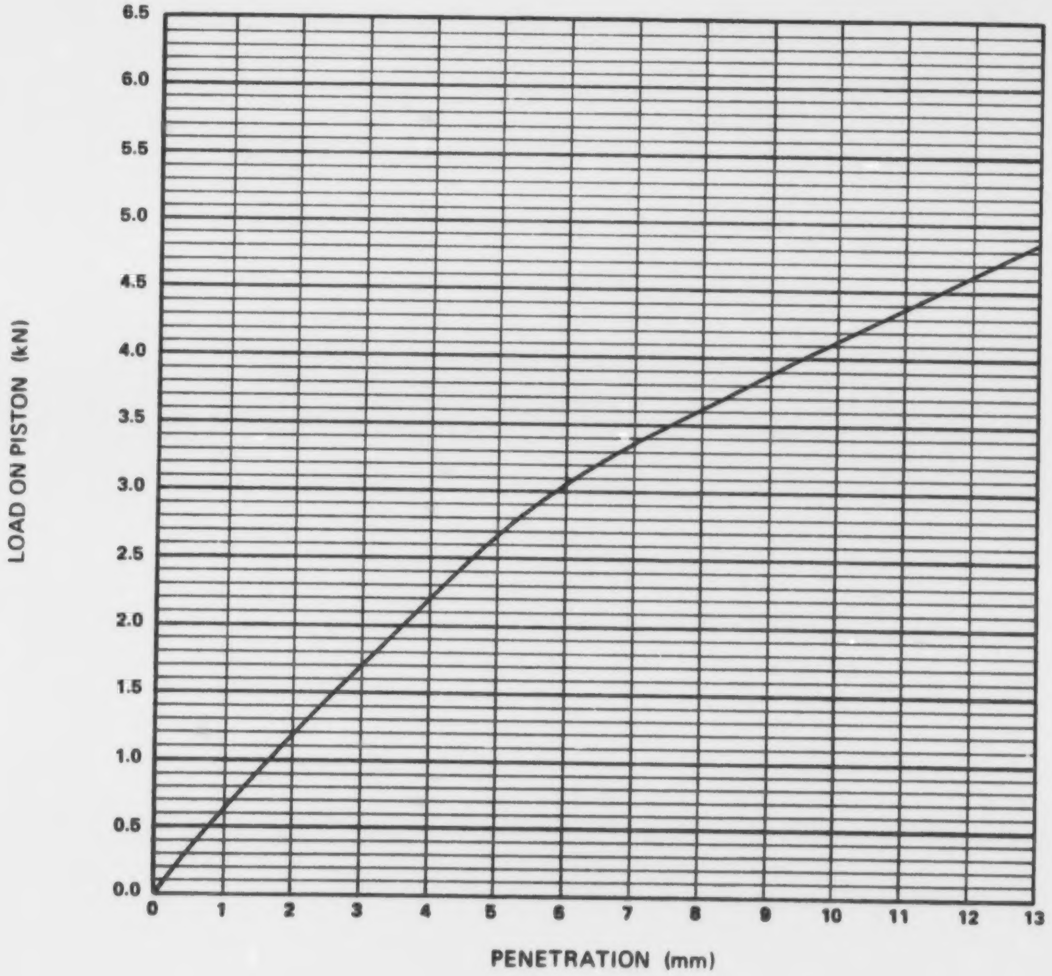
CEMENT 3 %

Final Moisture Content: 17.1 %

California Bearing Ratio: 2.5 mm 11 %

5.0 mm 14 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 100% of standard compactive effort, then cured at 20° C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Calgary: Bearspaw II
Sand 20%, Silt 56%, Clay 24%

Initial Dry Density: 1626 kg/m^3

Initial Moisture Content: 13.6 %

Stabilizer Dosage: FUJIBETON ____ %

FLYASH 9 %

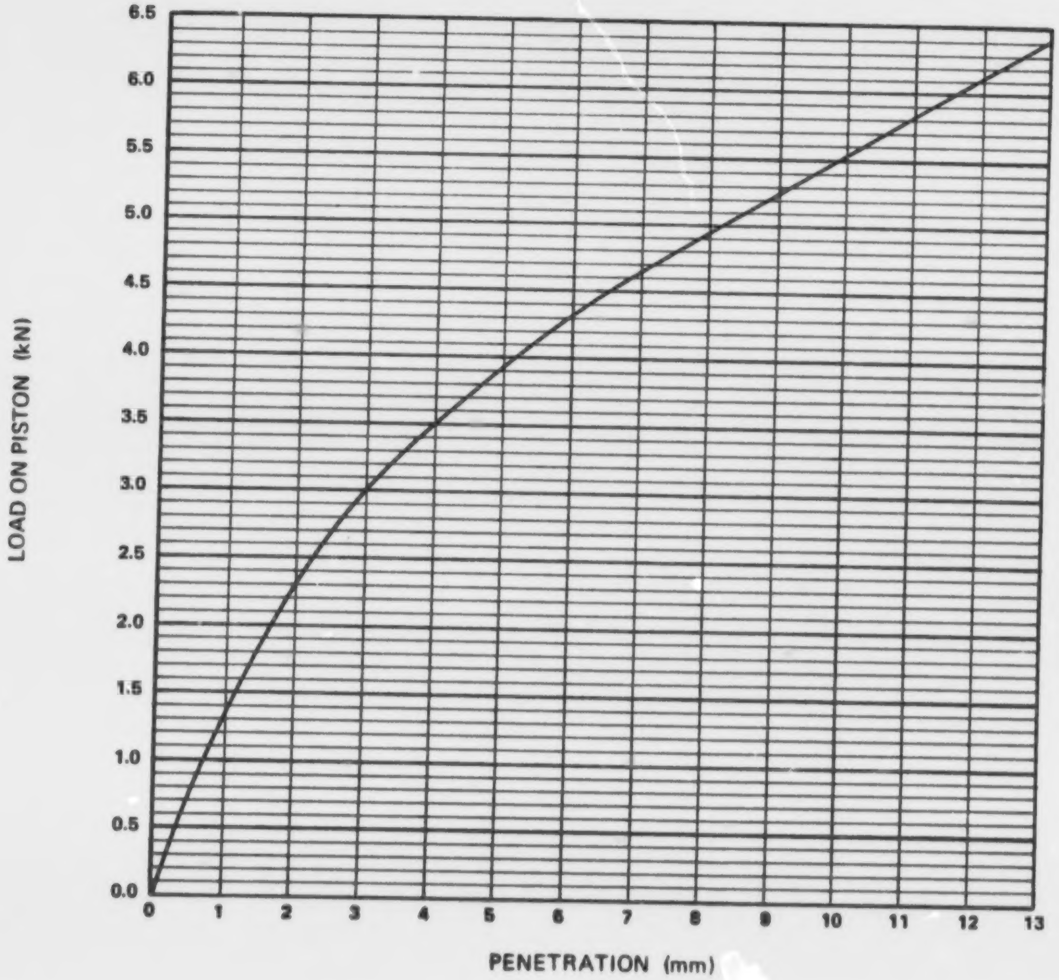
CEMENT 3 %

Final Moisture Content: 23.5 %

California Bearing Ratio: 2.5 mm 20 %

5.0 mm 20 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 100% of standard compactive effort, then cured at 20° C and 100% humidity for 7 days.



EBA Engineering Consultants Ltd.

eba

CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Calgary: Bearspaw II

Sand 20% , Silt 56% , Clay 24%

Initial Dry Density: 1640 kg/m^3

Initial Moisture Content: 13.2 %

Stabilizer Dosage: FUJIBETON ______ %

FLYASH 5 %

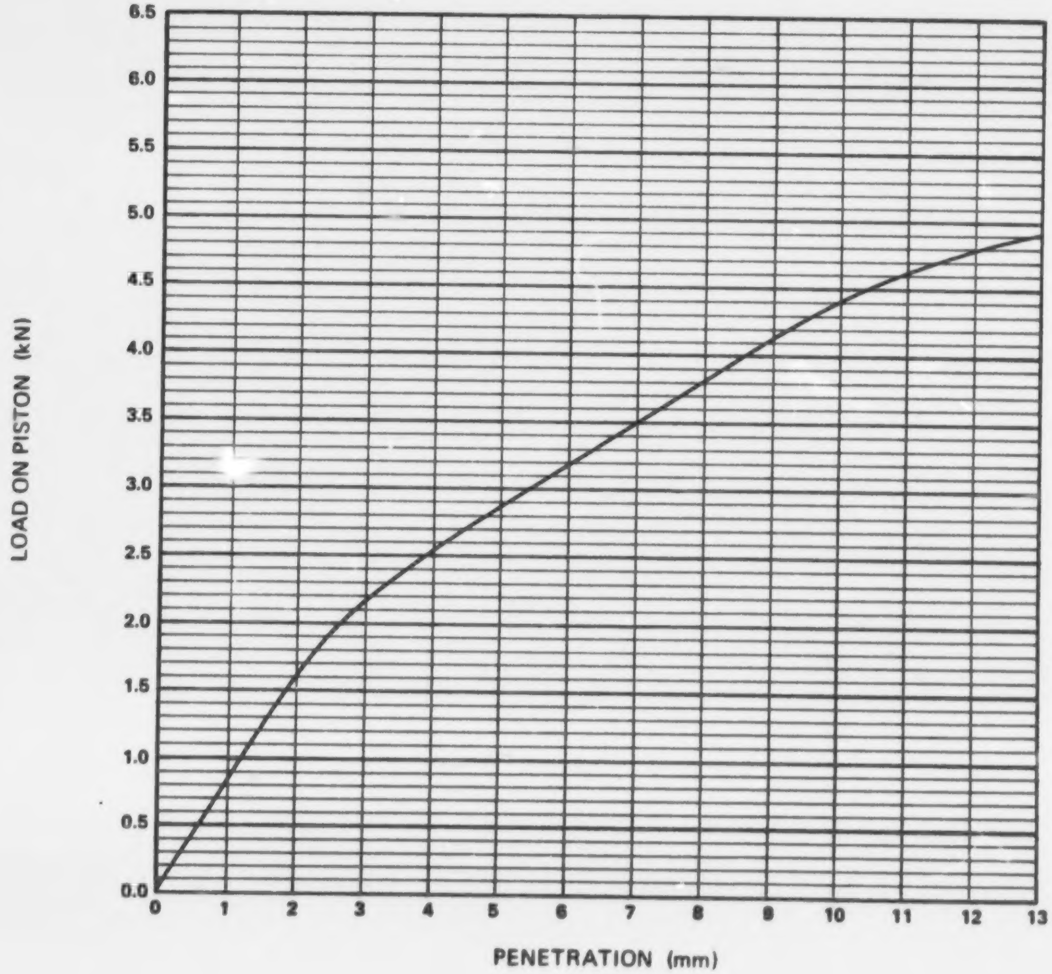
CEMENT 4 %

Final Moisture Content: 13.9 %

California Bearing Ratio: 2.5 mm 15 %

5.0 mm 15 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 100% of standard compactive effort, then cured at 20° C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Calgary: Bearspaw II

Sand 20%, Silt 56%, Clay 24%

Initial Dry Density: 1665 kg/m^3

Initial Moisture Content: 12.3 %

Stabilizer Dosage: FUJIBETON %

FLYASH 7 %

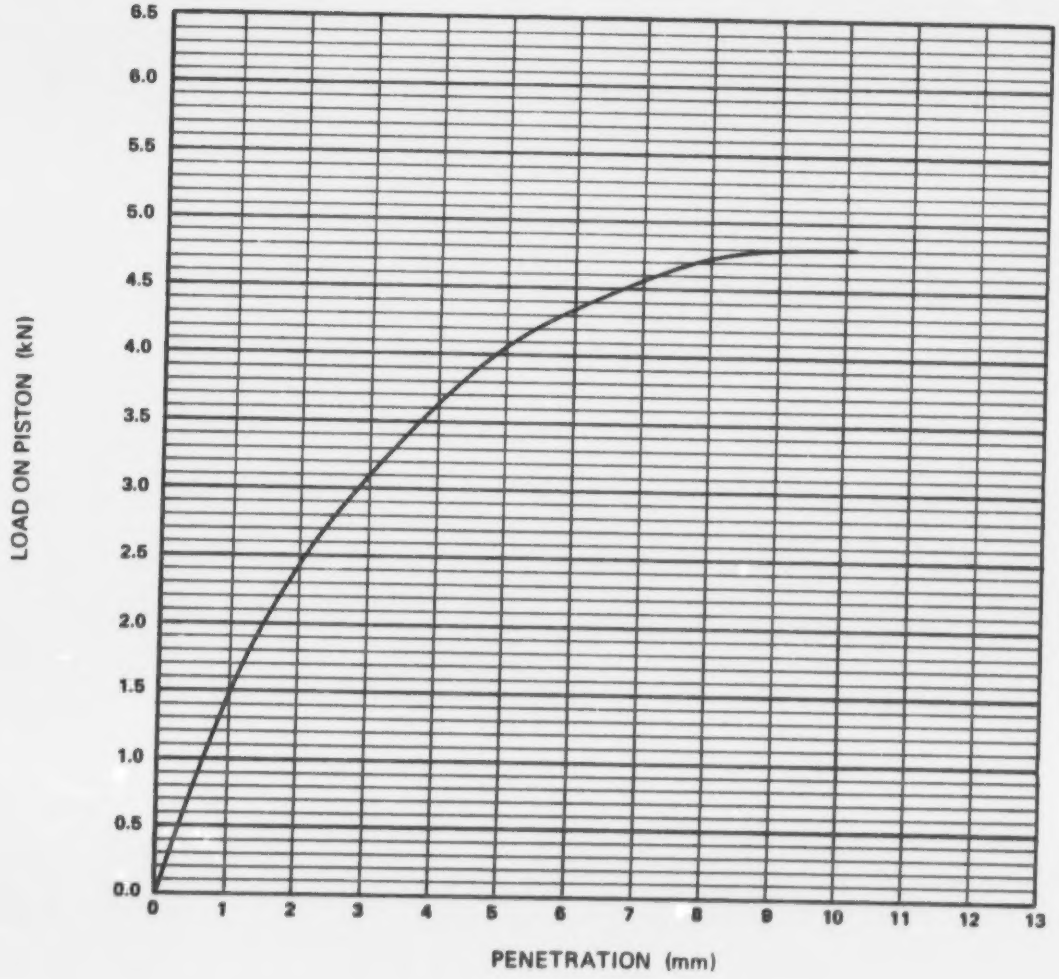
CEMENT 4 %

Final Moisture Content: 22.9 %

California Bearing Ratio: 2.5 mm 21 %

5.0 mm 21 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 100% of standard compactive effort, then cured at 20° C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA
Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Calgary: Bearspaw II
Sand 20% , Silt 56% , Clay 24%

Initial Dry Density: 1640 kg/m^3

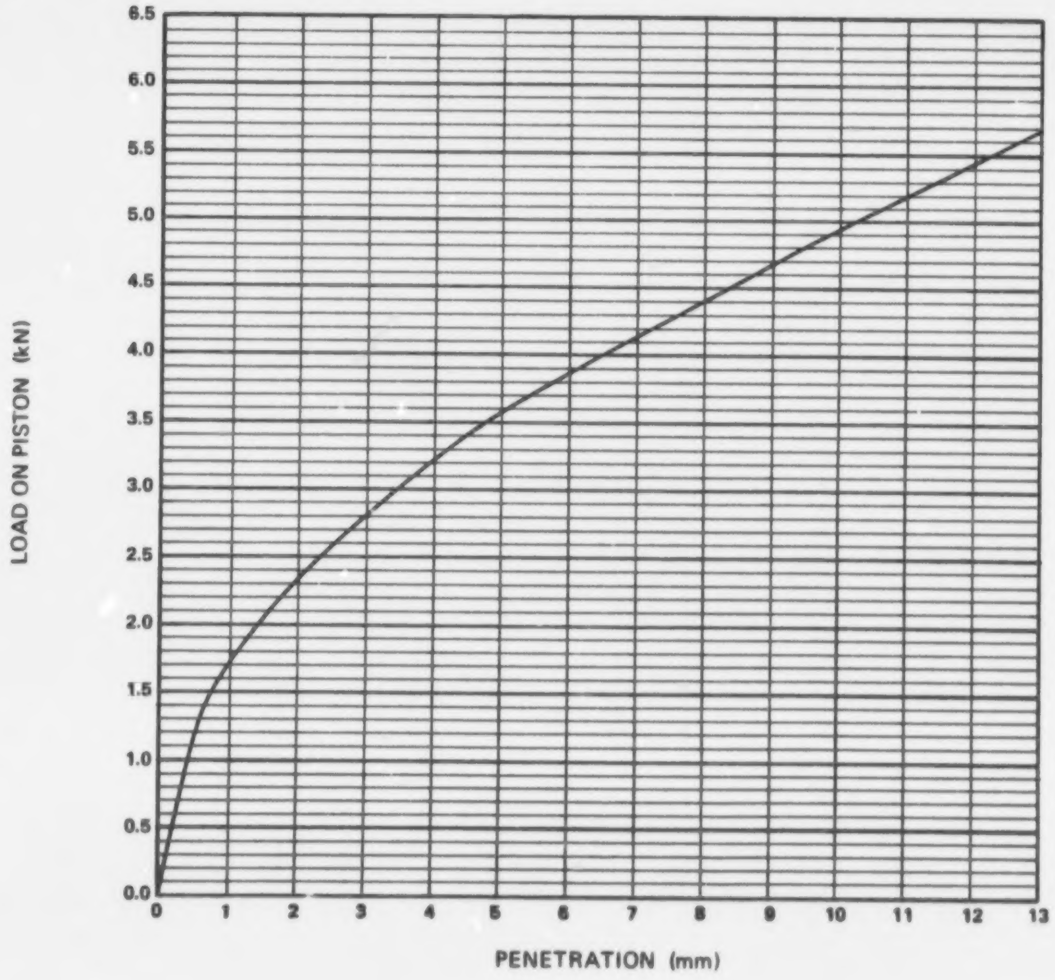
Initial Moisture Content: 13.4 %

Final Moisture Content: 23.7 %

California Bearing Ratio: 2.5 mm 20 %
5.0 mm 18 %

Stabilizer Dosage: FUJIBETON ______ %
FLYASH 9 %
CEMENT 4 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 100% of standard compactive effort, then cured at 20° C and 100% humidity for 7 days.



WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Project No.: 314 - 1264.02

Sample: Calgary: Bearspaw II
Sand 20 %, Silt 56 %, Clay 24 %

Contract No.: 1 SD 83 - 00026
Design Maximum Dry Density: 1730 kg/m^3
Design Optimum Moisture Content:% 13.5 %
Initial Dry Density: 1618 kg/m^3
Initial Moisture Content: 14.3 %
Initial Volume: 951.1 cm^3
Volume After Curing: 969.0 cm^3
Final Moisture Content: 21.2 %
Stabilized Soil Loss: 100 %

Stabilizer Dosage: FUJIBETON %
FLYASH 5 %
CEMENT 2 %

Method of Sample Preparation: ASTM D 559 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm^3)	VOLUME AFTER DRYING AND BRUSHING (cm^3)	WEIGHT AFTER DRYING AND BRUSHING (g)
1	963.4	918.5	1492.2
2	866.3	810.2	1315.0
3	848.3	810.8	1191.6
4	698.7	728.5	1078.3
5	614.2	692.8	964.3
6	683.3	596.4	857.4
7	614.2	589.6	768.5
8	497.7	491.2	684.5
9			
10			
11			
12			

Remarks: Sample disintegrated during ninth inundation.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 · 00026

Project No.: 314 · 1264.02

Design Maximum Dry Density: 1738 kg/m^3

Sample: Calgary: Bearspaw II

Design Optimum Moisture Content:% 13.7 %

Sand 20 %, Silt 56 %, Clay 24 %

Initial Dry Density: 1632 kg/m^3

Initial Moisture Content: 14.4 %

Initial Volume: 932.6 cm^3

Stabilizer Dosage FUJIBETON %

Volume After Curing: 940.9 cm^3

FLYASH 7 %

Final Moisture Content: 18.2 %

CEMENT 2 %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 559 · 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm^3)	VOLUME AFTER DRYING AND BRUSHING (cm^3)	WEIGHT AFTER DRYING AND BRUSHING (g)
1	940.7	926.1	1545.6
2	898.5	907.5	1455.8
3	871.8	851.5	1386.7
4	841.0	851.6	1335.2
5	812.0	827.8	1288.5
6	803.6	831.5	1221.9
7	---	---	---
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during handling after seventh inundation.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1705 kg/m³

Sample: Calgary: Bearspaw II

Sand 20 %, Silt 56 %, Clay 24 %

Design Optimum Moisture Content:% 14.0 %

Initial Dry Density: 1587 kg/m³

Initial Moisture Content: 15.4 %

Initial Volume: 949.2 cm³

Stabilizer Dosage: FUJIBETON _____ %

FLYASH 10 %

CEMENT 2 %

Volume After Curing: 954.0 cm³

Final Moisture Content: 21.5 %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 559 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm³)	VOLUME AFTER DRYING AND BRUSHING (cm³)	WEIGHT AFTER DRYING AND BRUSHING (g)
1	935.5	922.2	1448.4
2	880.1	843.6	1296.8
3	806.4	809.7	1196.3
4	769.7	724.2	1092.1
5	723.2	762.3	1018.7
6	735.6	589.2	906.5
7	591.2		
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during handling after seventh inundation.

EBA Engineering Consultants Ltd.

eba

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density 1725 kg/m^3

Sample: Calgary: Bearspaw II

Design Optimum Moisture Content % 14.0 %

Sand 20 %, Silt 56 %, Clay 24 %

Initial Dry Density 1650 kg/m^3

Initial Moisture Content 12.8 %

Initial Volume 941.2 cm^3

Stabilizer Dosage FUJIBETON %

Volume After Curing 943.6 cm^3

FLYASH 5 %

Final Moisture Content --- %

CEMENT 3 %

Stabilized Soil Loss 28 %

Method of Sample Preparation: ASTM D 559 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA

CYCLE	VOLUME AFTER SOAKING (cm^3)	VOLUME AFTER DRYING AND BRUSHING (cm^3)	WEIGHT AFTER DRYING AND BRUSHING (g)
1	955.5	934.5	1581.7
2	928.4	931.5	1531.6
3	930.5	923.5	1490.1
4	916.9	903.5	1449.4
5	867.5	859.8	1417.4
6	870.0	895.3	1385.5
7	924.0	840.2	1343.7
8	873.6	859.7	1317.0
9	870.7	849.8	1274.7
10	835.2	758.2	1233.6
11	828.0	726.2	1188.0
12	768.0	722.5	1144.7

Remarks: Unconfined Compressive Strength after durability test determined as 0.56 MPa.

EBA Engineering Consultants Ltd.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1720 kg/m3

Sample: Calgary: Bearspaw II

Sand 20 %, Silt 56 %, Clay 24 %

Design Optimum Moisture Content:% 13.0 %

Initial Dry Density: 1621 kg/m3

Initial Moisture Content: 13.2 %

Initial Volume: 946.1 cm3

Stabilizer Dosage FUJIBETON ______ %

FLYASH 9 %

CEMENT 3 %

Volume After Curing: 963.8 cm3

Final Moisture Content: 20.0 %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 559 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm^3)	VOLUME AFTER DRYING AND BRUSHING (cm^3)	WEIGHT AFTER DRYING AND BRUSHING (g)
1	955.4	945.8	1569.4
2	945.7	940.8	1508.3
3	931.5	929.0	1480.4
4	941.2	935.5	1428.0
5	933.4	900.7	1412.8
6	858.0	880.2	1385.9
7	919.7	863.5	1340.9
8	821.9	855.9	1322.4
9	871.1	811.8	1268.3
10	---	---	---
11			
12			

Remarks: Sample disintegrated during tenth inundation.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1722 kg/m3

Sample: Calgary: Bearspaw II

Sand 20 %, Silt 56 %, Clay 24 %

Design Optimum Moisture Content:%: 13.5 %

Initial Dry Density: 1626 kg m3

Initial Moisture Content: 13.2 %

Initial Volume: 940.9 cm3

Volume After Curing: 966.4 cm3

Final Moisture Content: --- %

Stabilized Soil Loss: 18 %

Stabilizer Dosage
FUJIBETON %
FLYASH 5 %
CEMENT 4 %

Method of Sample Preparation: ASTM D 559 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm3)	VOLUME AFTER DRYING AND BRUSHING (cm3)	WEIGHT AFTER DRYING AND BRUSHING (g)
1	951.0	942.9	1555.9
2	941.3	923.7	1522.9
3	931.8	945.7	1491.5
4	953.5	915.3	1455.9
5	873.5	924.1	1447.5
6	924.1	842.7	1427.5
7	901.9	895.0	1392.7
8	929.3	866.0	1387.2
9	872.6	884.9	1355.2
10	905.8	792.5	1334.6
11	861.1	802.5	1315.6
12	800.9	784.9	1284.6

Remarks: Unconfined Compressive Strength after durability test determined as 1.2 MPa.

EBA Engineering Consultants Ltd.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 · 00026

Project No.: 314 · 1264.02

Design Maximum Dry Density: 1742 kg/m3

Sample: Calgary: Bearspaw II

Design Optimum Moisture Content:% 13.0 %

Sand 20 %, Silt 56 %, Clay 24 %

Initial Dry Density: 1640 kg/m3

Initial Moisture Content: 13.6 %

Initial Volume: 961.8 cm3

Stabilizer Dosage: FUJIBETON ______ %

Volume After Curing: 971.5 cm3

FLYASH 7 %

Final Moisture Content: --- %

CEMENT 4 %

Stabilized Soil Loss: 14 %

Method of Sample Preparation: ASTM D 559 · 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm^3)	VOLUME AFTER DRYING AND BRUSHING (cm^3)	WEIGHT AFTER DRYING AND BRUSHING (g)
1	957.9	944.3	1616.9
2	934.9	932.2	1583.5
3	949.4	940.0	1564.3
4	929.9	934.9	1526.9
5	938.7	920.9	1522.4
6	900.5	935.9	1505.5
7	920.9	908.2	1466.6
8	893.7	941.4	1467.0
9	880.0	895.9	1440.6
10	908.8	837.5	1413.3
11	841.3	842.5	1401.6
12	857.0	813.2	1370.8

Remarks: Unconfined Compressive Strength after durability test determined as 1.5 MPa.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1710 kg/m³

Sample: Calgary: Bearspaw II

Sand 20 %, Silt 56 %, Clay 24 %

Design Optimum Moisture Content: % 14.5 %

Initial Dry Density: 1624 kg/m³

Initial Moisture Content: 13.9 %

Initial Volume: 956.8 cm³

Volume After Curing: 992.9 cm³

Final Moisture Content: --- %

Stabilized Soil Loss: 18 %

Stabilizer Dosage:

FUJIBETON _____ %

FLYASH 9 %

CEMENT 4 %

Method of Sample Preparation: ASTM D 559 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm³)	VOLUME AFTER DRYING AND BRUSHING (cm³)	WEIGHT AFTER DRYING AND BRUSHING (g)
1	958.6	956.2	1586.4
2	960.9	957.4	1530.6
3	937.8	920.6	1508.4
4	909.9	937.4	1464.9
5	920.1	924.2	1441.5
6	922.7	902.0	1431.7
7	881.1	920.4	1393.5
8	917.9	877.8	1389.3
9	879.2	855.6	1367.2
10	894.2	803.8	1340.5
11	809.4	795.1	1328.3
12	780.9	737.6	1304.3

Remarks: Unconfined Compressive Strength after durability test determined as 1.3 MPa.

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA	Contract No.: 1 SD 83 - 00026
Project No.: 314 - 1264.02	Design Maximum Dry Density: 1730 kg/m³
Sample: Calgary: Bearspaw II	Design Optimum Moisture Content: 13.5 %
Sand 20 %, Silt 56 %, Clay 24 %	Initial Dry Density: 1629 kg/m³
	Initial Moisture Content: 13.8 %
	Initial Volume: 937.4 cm³
Stabilizer Dosage: FUJIBETON ____ %	Volume After Curing: 958.6 cm³
FLYASH 5 %	Final Moisture Content: 20.8 %
CEMENT 2 %	Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 560 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm³)	WEIGHT AFTER THAWING AND BRUSHING (g)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated during first thawing period

EBA Engineering Consultants Ltd.

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No: 314 - 1264.02

Design Maximum Dry Density: 1738 kg/m3

Sample: Calgary: Bearspaw II

Sand 20 %, Silt 56 %, Clay 24 %

Design Optimum Moisture Content: 13.7 %

Initial Dry Density: 1643.4 kg/m3

Initial Moisture Content: 13.5 %

Initial Volume: 913.3 cm3

Volume After Curing: 926.9 cm3

Final Moisture Content: 21.7 %

Stabilized Soil Loss: 100 %

Stabilizer Dosage: FUJIBETON %

FLYASH 7 %

CEMENT 2 %

Method of Sample Preparation: ASTM D 560 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm^3)	WEIGHT AFTER THAWING AND BRUSHING (g)
1	889.2	1766.0
2	878.3	1645.9
3	710.3	1479.0
4	680.0	1324.0
5	698.3	1332.8
6	548.0	1108.3
7	520.4	973.6
8	429.0	856.0
9	411.0	773.3
10	384.7	690.0
11	343.2	627.1
12		

Remarks: Sample disintegrated during brushing after twelth thawing period

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1705 kg/m^3

Sample: Calgary: Bearspaw II

Design Optimum Moisture Content: 14.0 %

Sand 20 %, Silt 56 %, Clay 24 %

Initial Dry Density: 1600.2 kg/m^3

Initial Moisture Content: 14.6 %

Initial Volume: 945.6 cm^3

Stabilizer Dosage: FUJIBETON %

FLYASH 10 %

CEMENT 2 %

Volume After Curing: 975.2 cm^3

Final Moisture Content: 23.4 %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 560 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm^3)	WEIGHT AFTER THAWING AND BRUSHING (g)
1	865.6	1638.6
2	938.0	1290.3
3	550.1	992.3
4	438.9	836.5
5	340.1	644.6
6	268.7	509.9
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated during seventh thawing period

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Project No.: 314 - 1264.02

Sample: Calgary: Bearspaw II

Sand 20 %, Silt 56 %, Clay 24 %

Stabilizer Dosage: FUJIBETON ____ %

FLYASH 5 %

CEMENT 3 %

Contract No.: 1 SD 83 - 00026

Design Maximum Dry Density: 1725 kg/m³

Design Optimum Moisture Content: 14.0 %

Initial Dry Density: 1631 kg/m³

Initial Moisture Content: 13.9 %

Initial Volume: 943.5 cm³

Volume After Curing: 984.9 cm³

Final Moisture Content: 25.0 %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 560 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm³)	WEIGHT AFTER THAWING AND BRUSHING (g)
1	946.2	1826.5
2	877.6	1734.0
3	813.8	1567.3
4	800.3	1441.6
5	732.2	1328.7
6	607.4	1187.5
7	572.0	1058.9
8	559.5	964.7
9	459.2	861.1
10	445.4	795.7
11		
12		

Remarks: Sample disintegrated during brushing after eleventh thawing period

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client:	TRANSPORT CANADA	Contract No.:	1 SD 83 · 00026
Project No.:	314 · 1264.02	Design Maximum Dry Density:	1720 kg/m³
Sample:	Calgary: Bearspaw II	Design Optimum Moisture Content:	13.0 %
	Sand 20 %, Silt 56 %, Clay 24 %	Initial Dry Density:	1600 kg/m³
		Initial Moisture Content:	14.0 %
		Initial Volume:	952.6 cm³
Stabilizer Dosage: FUJIBETON	%	Volume After Curing:	961.1 cm³
FLYASH	9 %	Final Moisture Content:	22.8 %
CEMENT	3 %	Stabilized Soil Loss:	100 %

Method of Sample Preparation: ASTM D 560 · 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm³)	WEIGHT AFTER THAWING AND BRUSHING (g)
1	961.1	1802.7
2	907.2	1688.3
3	785.7	1537.3
4	758.7	1400.8
5	678.9	1243.9
6	621.9	1132.0
7	559.0	1005.1
8		
9		
10		
11		
12		

Remarks: Sample disintegrated during brushing after eighth thawing period

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1722 kg/m^3

Sample: Calgary: Bearspaw II

Design Optimum Moisture Content: 13.5 %

Sand 20 %, Silt 56 %, Clay 24 %

Initial Dry Density: 1642 kg/m^3

Initial Moisture Content: 12.5 %

Initial Volume: 928.1 cm^3

Stabilizer Dosage: FUJIBETON %

Volume After Curing: 953.0 cm^3

FLYASH 5 %

Final Moisture Content: 22.4 %

CEMENT 4 %

Stabilized Soil Loss: 46 %

Method of Sample Preparation: ASTM D 560 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm^3)	WEIGHT AFTER THAWING AND BRUSHING (g)
1	955.0	1854.3
2	941.4	1829.5
3	938.0	1784.0
4	900.4	1725.0
5	917.1	1734.8
6	807.2	1570.5
7	710.1	1433.8
8	680.8	1344.7
9	659.9	1262.2
10	634.0	1201.6
11	632.9	1140.9
12	532.7	1050.0

Remarks: Unconfined compressive strength after durability test determined as 0.57 MPa

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1742 kg/m³

Sample: Calgary: Bearspaw II

Design Optimum Moisture Content: 13.0 %

Sand 20 %, Silt 56 %, Clay 24 %

Initial Dry Density: 1643.4 kg/m³

Initial Moisture Content: 13.1 %

Initial Volume: 958.7 cm³

Stabilizer Dosage: FUJIBETON %

Volume After Curing: 971.1 cm³

FLYASH 7 %

Final Moisture Content: 22.8 %

CEMENT 4 %

Stabilized Soil Loss: 45 %

Method of Sample Preparation: ASTM D 560 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm³)	WEIGHT AFTER THAWING AND BRUSHING (g)
1	962.8	1868.5
2	968.9	1847.5
3	857.9	1806.1
4	939.5	1764.6
5	841.1	1691.4
6	868.5	1614.2
7	834.3	1492.0
8	789.5	1398.6
9	695.4	1318.4
10	675.8	1246.1
11	646.5	1180.6
12	610.7	1081.9

Remarks: Unconfined compressive strength after durability test determined as 0.56 MPa

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1710 kg/m^3

Sample: Calgary: Bearspaw II

Design Optimum Moisture Content: 14.5 %

Sand 20 %, Silt 56 %, Clay 24 %

Initial Dry Density: 1607 kg/m^3

Initial Moisture Content: 14.8 %

Initial Volume: 931.4 cm^3

Stabilizer Dosage: FUJIBETON %

Volume After Curing: 964.7 cm^3

FLYASH 9 %

Final Moisture Content: 22.8 %

CEMENT 4 %

Stabilized Soil Loss: 51 %

Method of Sample Preparation: ASTM D 560 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm^3)	WEIGHT AFTER THAWING AND BRUSHING (g)
1	946.6	1832.8
2	939.2	1793.5
3	913.3	1742.1
4	860.9	1672.5
5	820.0	1563.2
6	787.8	1465.6
7	734.7	1347.3
8	674.3	1245.7
9	646.3	1156.9
10	603.6	1099.6
11	552.8	1038.0
12	516.3	946.1

Remarks: Unconfined compressive strength after durability test determined as 0.63 MPa

APPENDIX C

LABORATORY TEST RESULTS
CALGARY AIRPORT

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1SD83 - 00026

Project No.: 314 - 1264.02

Stabilizer Dosage: FUJIBETON 0 %

Sample: Calgary: Airport

FLYASH 0 %

Sand 27 %, Silt 48 %, Clay 25 %

CEMENT 0 %

TEST DATA:

1) Method of Sample Preparation: ASTM D 558 - 57

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	4.8	1741
2	10.0	1754
3	14.2	1818
4	20.1	1695
5	24.5	1544

Design Field Optimum Moisture Content: 14.5 %

Design Field Maximum Dry Density: 1820 kg/m³

2) Method of Sample Preparation: ASTM D558 - 57, but using 19 blows to compact each layer instead of 25 blows

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	5.1	1690
2	9.2	1667
3	12.7	1799
4	19.6	1683
5	23.8	1562

Design Field Optimum Moisture Content: 14.0 %

Design Field Maximum Dry Density: 1810 kg/m³

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

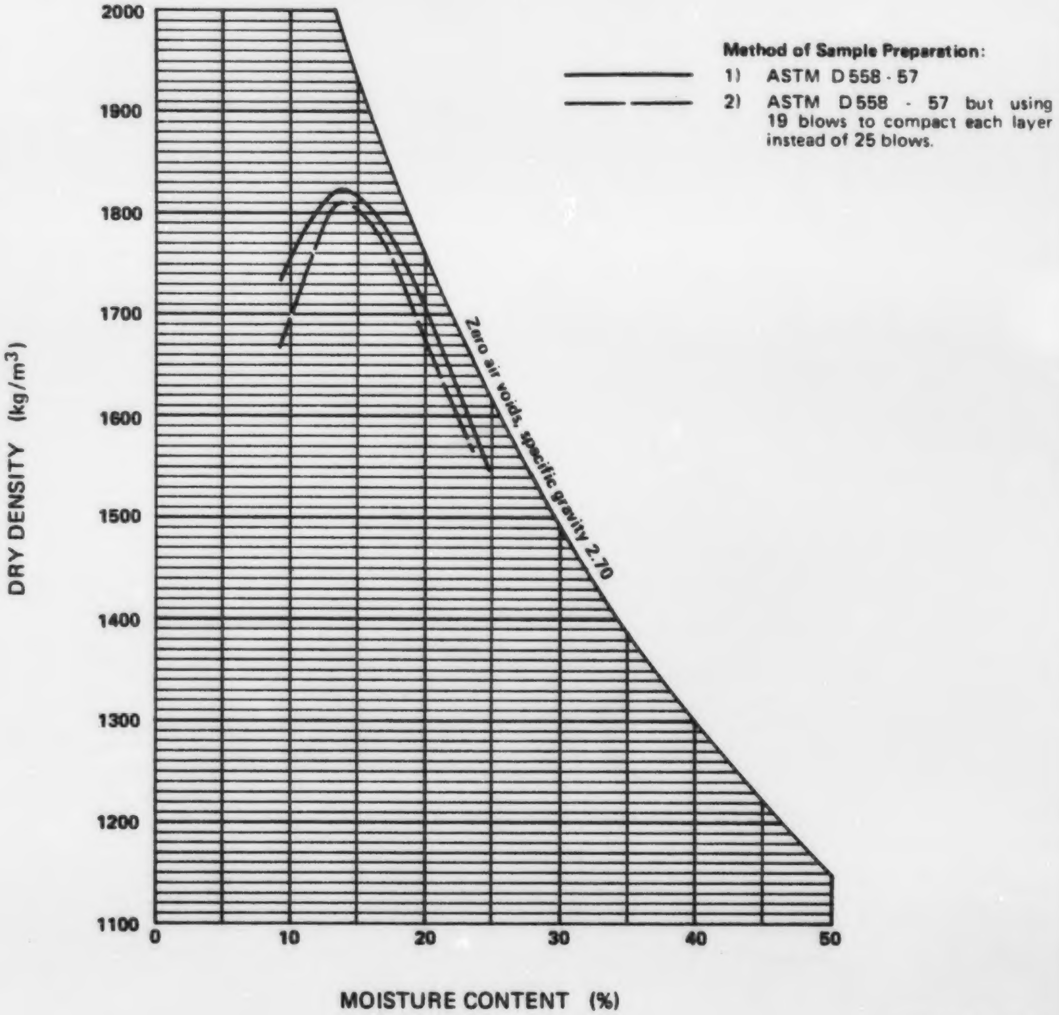
Stabilizer Dosage: FUJIBETON 0 %

Sample: Calgary: Airport

FLYASH 0 %

Sand 27 %, Silt 48 %, Clay 25 %

CEMENT 0 %



SHEET 2 OF 2

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1SD83 - 00026

Project No.: 314 - 1264.02

Stabilizer Dosage: FUJIBETON 0 %

FLYASH 0 %

CEMENT 0 %

Sample: Calgary: Airport

Sand 27%, Silt 48%, Clay 25%

TEST DATA:

1) Method of Sample Preparation: ASTM D 558 - 57

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	7.2	1695
2	12.4	1782
3	16.4	1774
4	21.6	1632
5	26.3	1514

Design Field Optimum Moisture Content: 14.5 %

Design Field Maximum Dry Density: 1820 kg/m³

2) Method of Sample Preparation: ASTM D558 - 57, but using 19 blows to compact each layer instead of 25 blows

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	4.2	1662
2	10.6	1693
3	14.5	1805
4	18.3	1736
5	23.6	1581

Design Field Optimum Moisture Content: 14.0 %

Design Field Maximum Dry Density: 1810 kg/m³

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lig[illegible]ulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Calgary: Airport

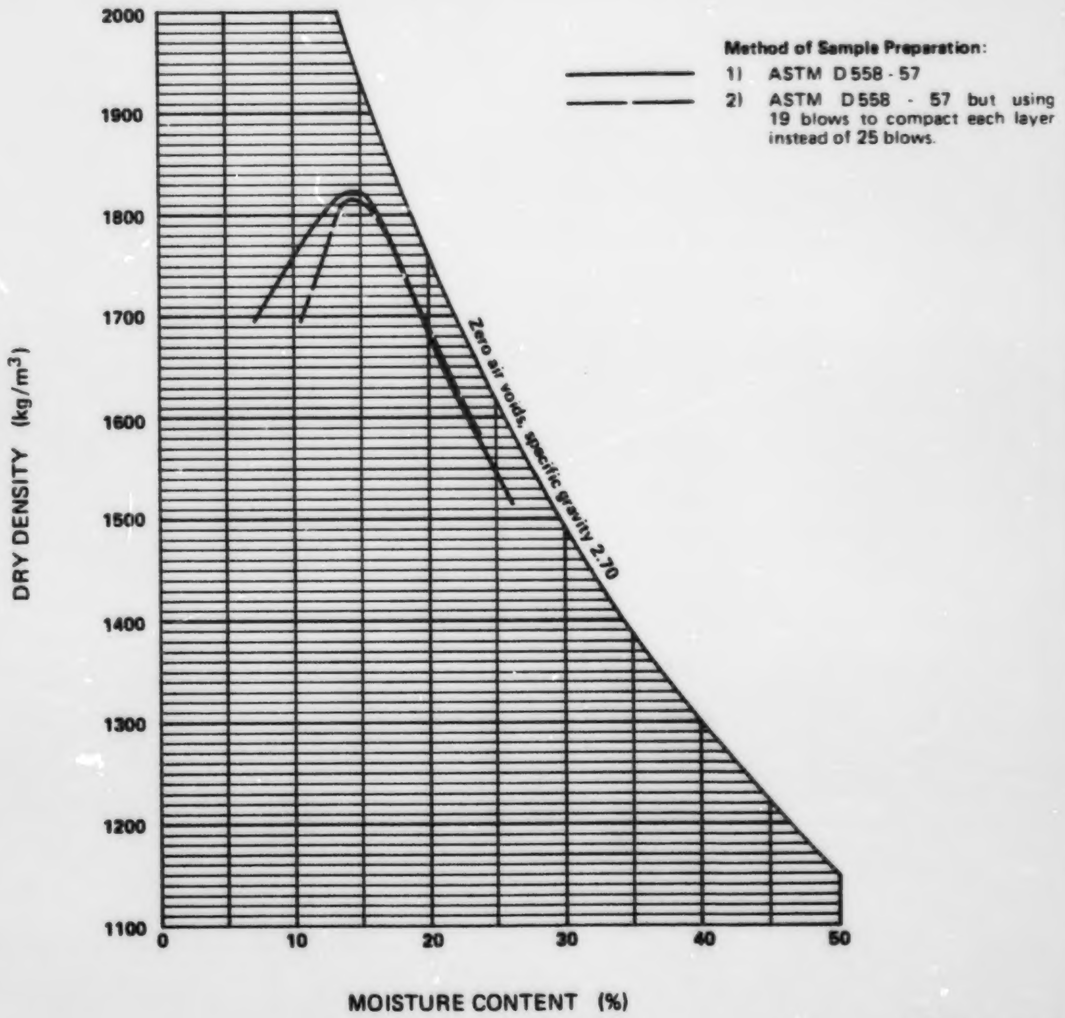
Sand 27% , Silt 48% , Clay 25%

Stabilizer Dosage:

FUJIBETON 0 %

FLYASH 0 %

CEMENT 0 %



SHEET 2 OF 2

CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02 Stabilizer Dosage: None

Sample: Calgary: Airport

Sand 27%, Silt 48%, Clay 25%

Samples compacted using 100% of standard energy

TEST	DRY DENSITY (kg/m^3)	MOISTURE CONTENT (%)	CALIFORNIA BEARING RATIO (%)	
			2.5 mm Penetration	5.0 mm Penetration
1	1695	7.2	19	23
2	1782	12.4	13	14
3	1774	16.4	4.5	4.6
4	1632	21.6	0.8	0.7
5	1514	26.3	0.3	0.2
6	1741	4.8	25	27
7	1754	10.0	14	14
8	1818	14.2	7.8	7.3
9	1695	20.1	1.2	1.1
10	1544	24.5	0.1	0.1

CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02 Stabilizer Dosage: None

Sample: Calgary: Airport

Sand 27%, Silt 48%, Clay 25%

Samples compacted using 75 % of standard energy

TEST	DRY DENSITY (kg/m^3)	MOISTURE CONTENT (%)	CALIFORNIA BEARING RATIO (%)	
			2.5 mm Penetration	5.0 mm Penetration
1	1662	4.2	16	18
2	1693	10.2	19	15
3	1805	13.9	6.7	7.0
4	1736	17.9	3.0	2.4
5	1581	23.5	0.4	0.3
6	1690	4.8	25	30
7	1667	9.1	12	11
8	1799	13.6	8.2	7.7
9	1683	20.1	1.0	1.0
10	1562	24.2	0.4	0.3

ATTERBERG LIMITS TEST DATA

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264. 02

SAMPLE	STABILIZER DOSAGE (%)			REACTION TIME (hours)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX
	FUJIBETON	FLYASH	CEMENT				
Calgary: Airport	0	0	0	–	17.9	30.0	12.1
	1	–	–	0.25 (mix.)	20.8	32.0	11.2
	1	–	–	1	23.8	33.5	9.7
	1	–	–	24	21.4	33.2	11.8
	2	–	–	0.25 (mix.)	25.0	33.6	8.6
	2	–	–	1	25.8	34.8	9.0
	2	–	–	24	25.8	38.5	12.7
	4	–	–	0.25 (mix.)	22.5	30.2	7.7
	4	–	–	1	–	–	Non Plastic
	4	–	–	24	–	–	Non Plastic
	6	–	–	0.25 (mix.)	23.1	31.5	8.4
	6	–	–	1	–	–	Non Plastic
	6	–	–	24	–	–	Non Plastic
	10	–	–	0.25 (mix.)	23.5	31.5	8.0
	10	–	–	1	–	–	Non Plastic
	10	–	–	24	–	–	Non Plastic
	–	2	–	0.25 (mix.)	16.3	28.2	11.9
	–	2	–	1	16.9	30.1	13.2
	–	2	–	24	16.3	27.9	11.6
	–	6	–	0.25 (mix.)	17.0	27.6	10.6
	–	6	–	1	16.4	30.7	14.3
	–	6	–	24	16.3	27.7	11.4
	–	10	–	0.25 (mix.)	15.9	27.5	11.6
	–	10	–	1	17.4	28.8	11.4
	–	10	–	24	16.7	27.7	11.0
	–	13	–	0.25 (mix.)	16.5	27.8	11.3
	–	13	–	1	17.7	28.3	10.6

ATTERBERG LIMITS TEST DATA

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264. 02

SAMPLE	STABILIZER DOSAGE (%)			REACTION TIME (hours)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX
	FUJIBETON	FLYASH	CEMENT				
Calgary: Airport	–	13	–	24	16.7	27.6	10.9
	–	5	3	0.25 (mix.)	25.7	40.2	14.5
	–	5	3	1	25.6	31.0	5.4
	–	5	3	24	–	–	Non Plastic

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA
Contract No.: 1SD83 - 00026

Project No.: 314 - 1264.02
Stabilizer Dosage: FUJIBETON 1 %

Sample: Calgary: Airport
FLYASH %

Sand 27%, Silt 48%, Clay 25%
CEMENT %

TEST DATA:

1) Method of Sample Preparation: ASTM D 558 - 57

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	19.4	1670
2	13.6	1722
3	8.8	1655
4	23.5	1548
5		

Design Field Optimum Moisture Content: 10.6 %

Design Field Maximum Dry Density: 1747 kg/m³

2) Method of Sample Preparation: ASTM D558 - 57, but using 19 blows to compact each layer instead of 25 blows

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	10.2	1595
2	14.3	1629
3	19.8	1639
4	22.0	1603
5		

Design Field Optimum Moisture Content: 18.5 %

Design Field Maximum Dry Density: 1665 kg/m³

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

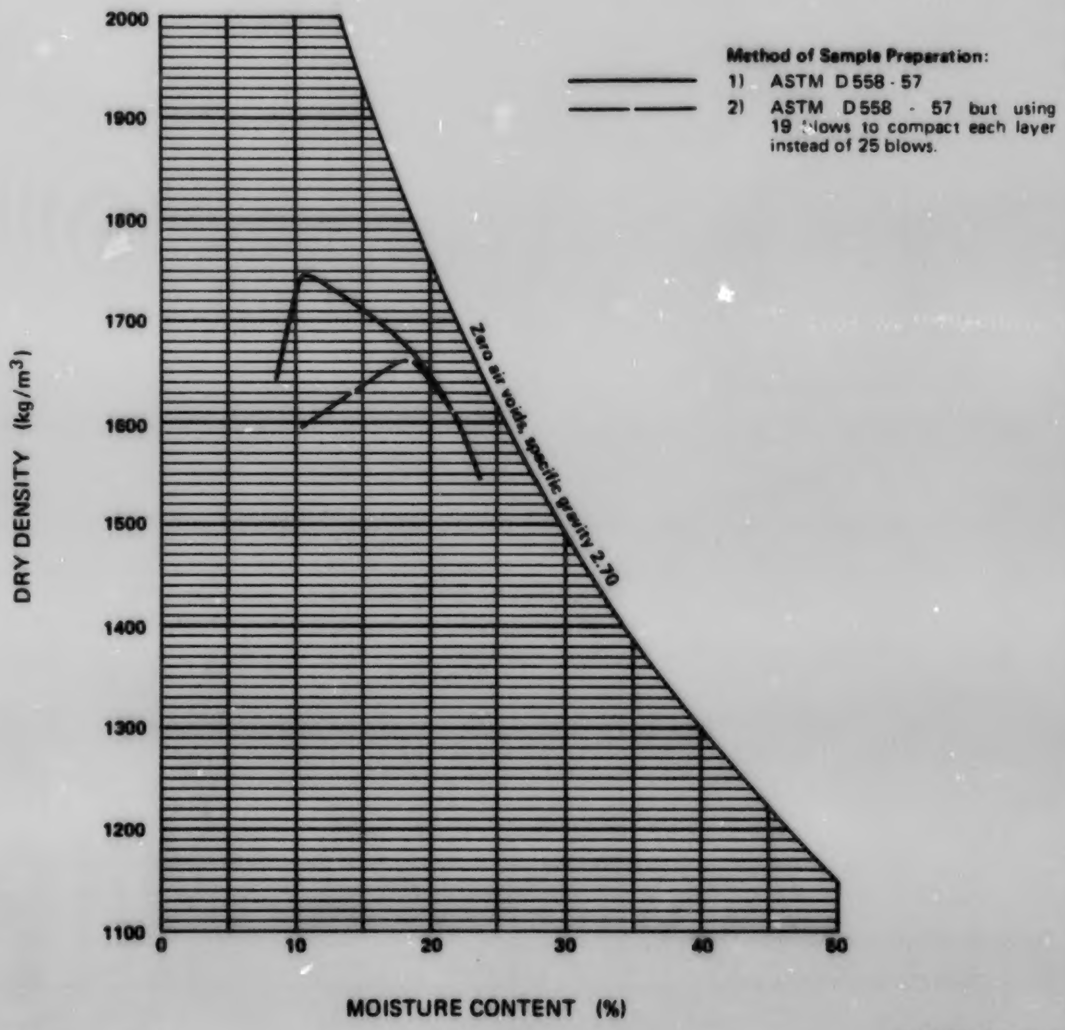
Stabilizer Dosage: FUJIBETON 1 %

Sample: Calgary: Airport

FLYASH %

Sand 27 %, Silt 48 %, Clay 25 %

CEMENT %



EBA Engineering Consultants Ltd.

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1SD83 - 00026

Project No.: 314 - 1264.02

Stabilizer Dosage: FUJIBETON 2 %

Sample: Calgary: Airport

FLYASH %

Sand 27%, Silt 48%, Clay 25%

CEMENT %

TEST DATA:

1) Method of Sample Preparation: ASTM D 558 - 57

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	18.4	1657
2	15.0	1681
3	10.3	1641
4	24.8	1522
5		

Design Field Optimum Moisture Content: 16.2 %

Design Field Maximum Dry Density: 1690 kg/m³

2) Method of Sample Preparation: ASTM D558 - 57, but using 19 blows to compact each layer instead of 25 blows

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	9.5	1611
2	14.4	1602
3	16.2	1689
4	22.4	1594
5		

Design Field Optimum Moisture Content: 17.2 %

Design Field Maximum Dry Density: 1695 kg/m³

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

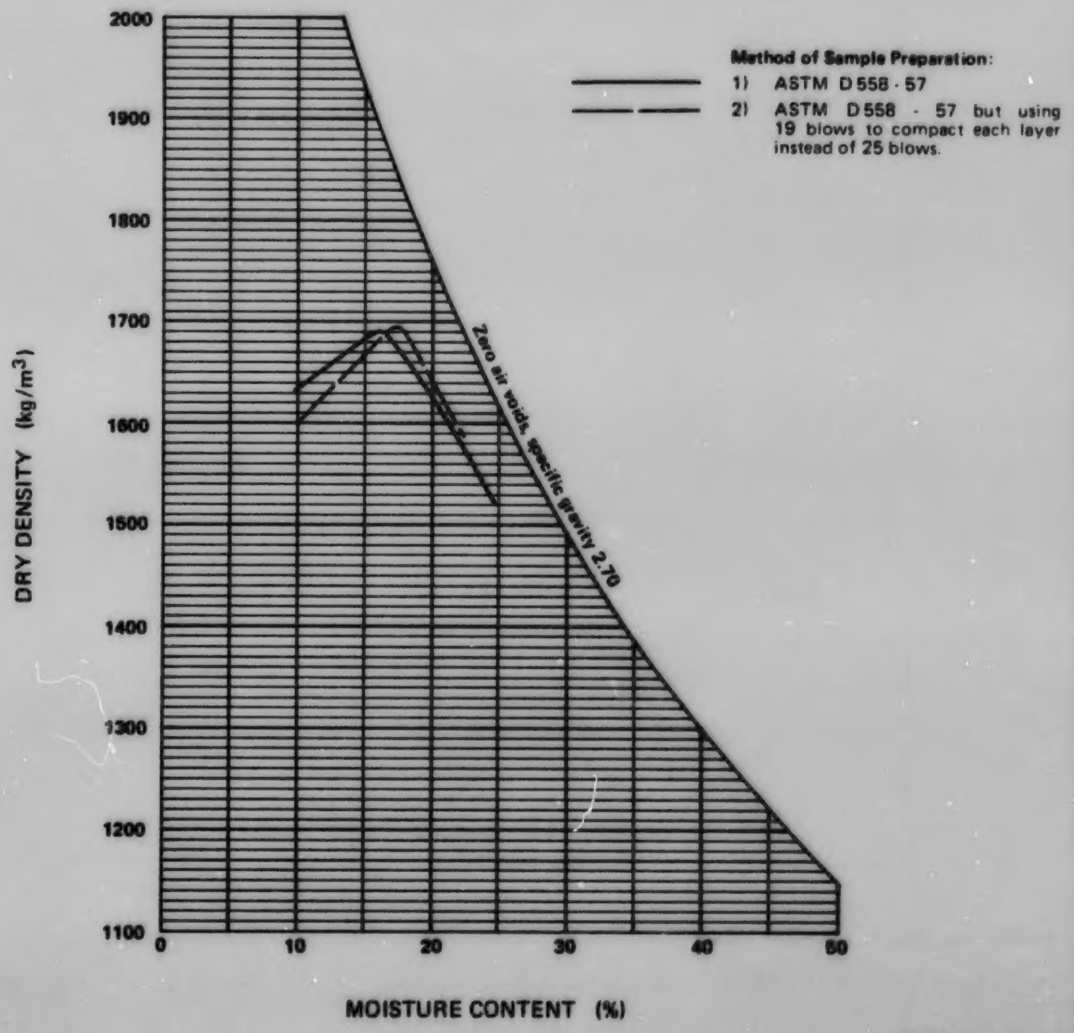
Stabilizer Dosage: FUJIBETON 2 %

Sample: Calgary: Airport

FLYASH %

Sand 27 %, Silt 48 %, Clay 25 %

CEMENT %



SHEET 2 OF 2

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA Contract No.: 1SD83 - 00026

Project No.: 314 - 1264.02 Stabilizer Dosage: FUJIBETON 4 %

Sample: Calgary: Airport FLYASH %

Sand 27%, Silt 48%, Clay 25% CEMENT %

TEST DATA:

1) Method of Sample Preparation: ASTM D 558 - 57

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	18.5	1691
2	15.1	1698
3	9.8	1653
4	25.0	1533
5		

Design Field Optimum Moisture Content: 16.7 %

Design Field Maximum Dry Density: 1712 kg/m³

2) Method of Sample Preparation: ASTM D558 - 57, but using 19 blows to compact each layer instead of 25 blows

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	9.5	1586
2	13.5	1649
3	15.4	1620
4	20.5	1631
5	25.9	1507

Design Field Optimum Moisture Content: 16.8 %

Design Field Maximum Dry Density: 1690 kg/m³

SHEET 1 OF 2

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

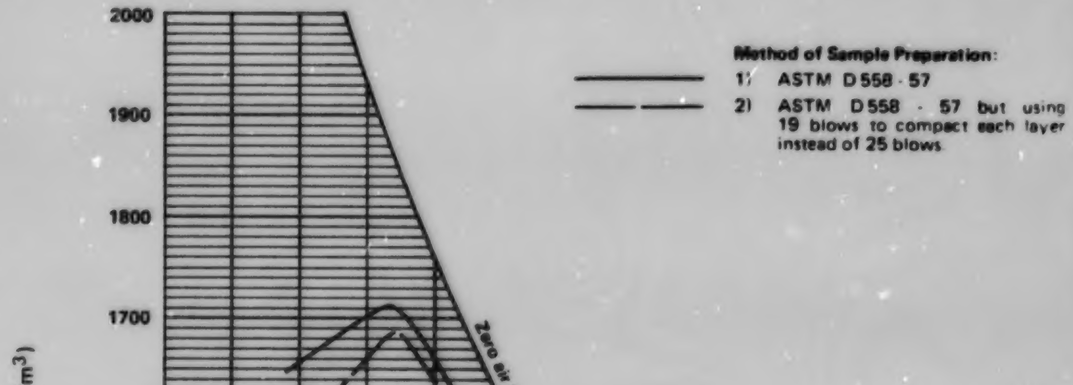
Stabilizer Dosage: FUJIBETON 4 %

Sample: Calgary: Airport

FLYASH %

Sand 27 %, Silt 48 %, Clay 25 %

CEMENT %



SHEET 2 OF 2

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA Contract No.: 1SD83 - 00026

Project No.: 314 - 1264.02 Stabilizer Dosage: FUJIBETON 6 %

Sample: Calgary: Airport FLYASH %

Sand 27%, Silt 48%, Clay 25% CEMENT %

TEST DATA:

1) Method of Sample Preparation: ASTM D 558 - 57

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	19.3	1691
2	17.0	1681
3	14.4	1627
4	26.4	1551
5		

Design Field Optimum Moisture Content: 18.2 %

Design Field Maximum Dry Density: 1700 kg/m³

2) Method of Sample Preparation: ASTM D558 - 57, but using 19 blows to compact each layer instead of 25 blows

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	9.0	1620
2	13.7	1633
3	20.3	1662
4	26.7	1478
5		

Design Field Optimum Moisture Content: 18.5 %

Design Field Maximum Dry Density: 1665 kg/m³

SHEET 1 OF 2

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

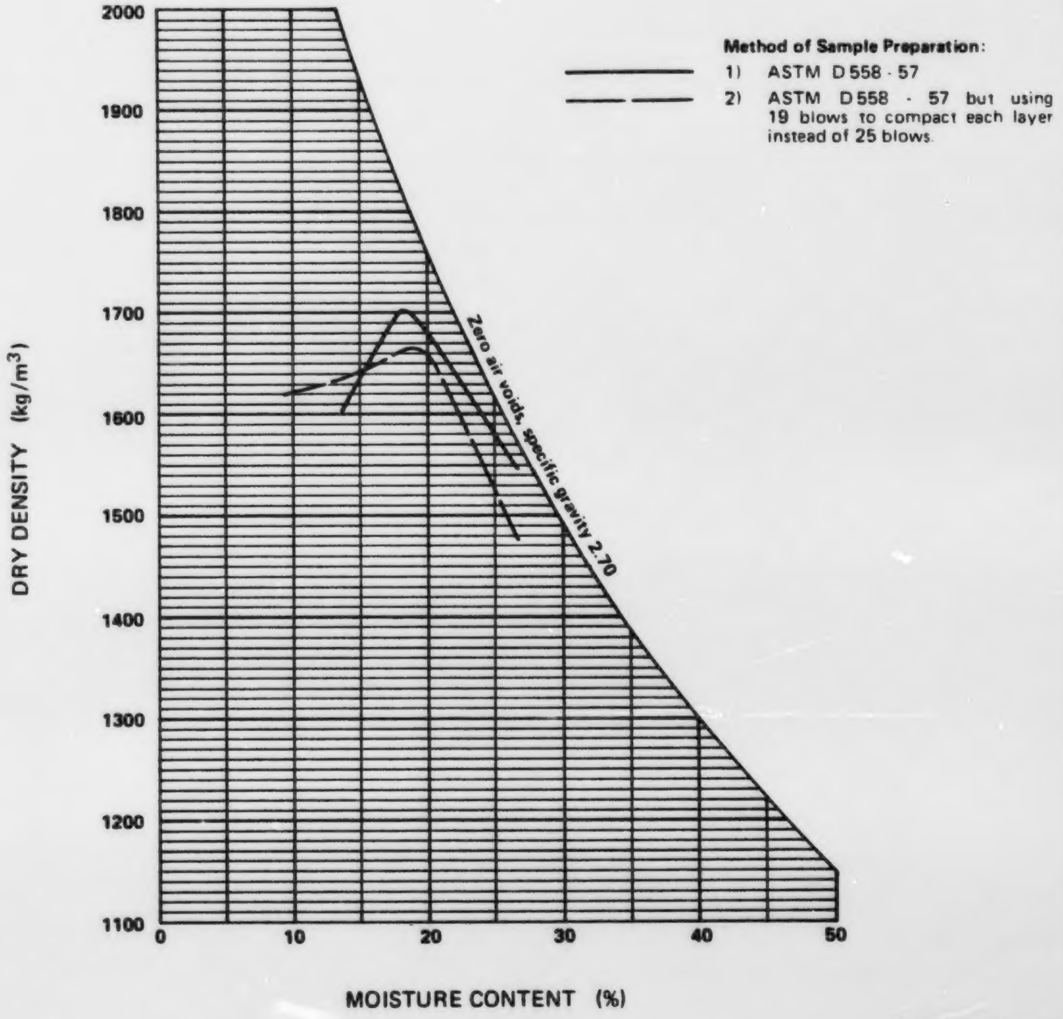
Stabilizer Dosage: FUJIBETON 6 %

FLYASH %

CEMENT %

Sample: Calgary: Airport

Sand 27 %, Silt 48 %, Clay 25 %



SHEET 2 OF 2

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1SD83 - 00026

Project No.: 314 - 1264.02

Stabilizer Dosage: FUJIBETON 10 %

FLYASH %

CEMENT %

Sample: Calgary: Airport

Sand 27%, Silt 48%, Clay 25%

TEST DATA:

1) Method of Sample Preparation: ASTM D 558 - 57

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	20.1	1690
2	14.5	1708
3	9.8	1714
4	23.4	1572
5	13.1	1657

Design Field Optimum Moisture Content: 16.8 %

Design Field Maximum Dry Density: 1731 kg/m³

2) Method of Sample Preparation: ASTM D558 - 57, but using 19 blows to compact each layer instead of 25 blows

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	8.7	1661
2	14.1	1680
3	19.2	1688
4	26.8	1500
5		

Design Field Optimum Moisture Content: 18 %

Design Field Maximum Dry Density: 1690 kg/m³

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

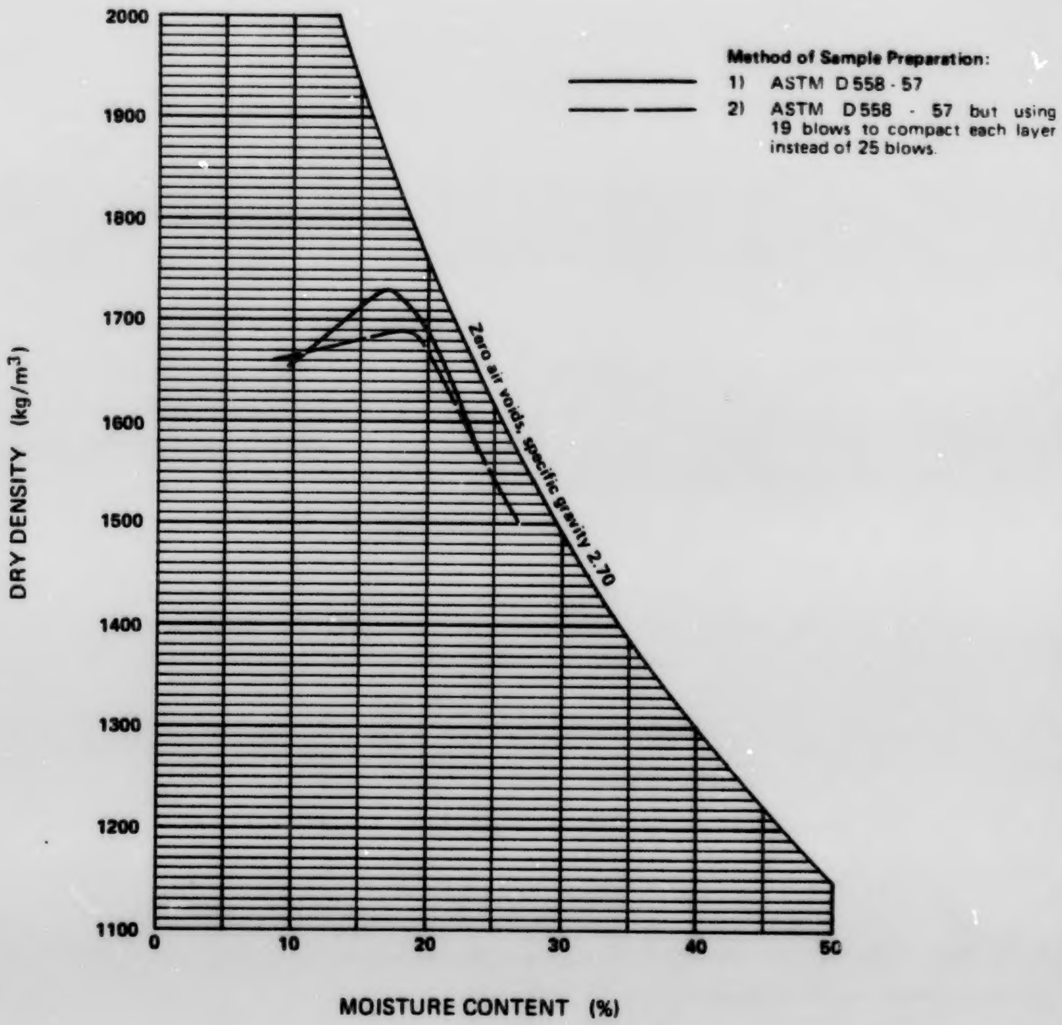
Stabilizer Dosage: FUJIBETON 10 %

FLYASH %

CEMENT %

Sample: Calgary: Airport

Sand 27 %, Silt 48 %, Clay 25 %



DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1SD83 - 00026

Project No.: 314 - 1264.02

Stabilizer Dosage: FUJIBETON %

Sample: Calgary: Airport

FLYASH 2 %

Sand 27%, Silt 48%, Clay 25%

CEMENT %

TEST DATA:

1) Method of Sample Preparation: ASTM D 558 - 57

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	5.7	1672
2	9.9	1731
3	15.8	1722
4	20.0	1637
5	24.4	1487

Design Field Optimum Moisture Content: 12.8 %

Design Field Maximum Dry Density: 1765 kg/m³

2) Method of Sample Preparation: ASTM D558 - 57, but using 19 blows to compact each layer instead of 25 blows

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	9.7	1568
2	17.6	1670
3	19.5	1661
4	24.3	1518
5		

Design Field Optimum Moisture Content: 18.5 %

Design Field Maximum Dry Density: 1675 kg/m³

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

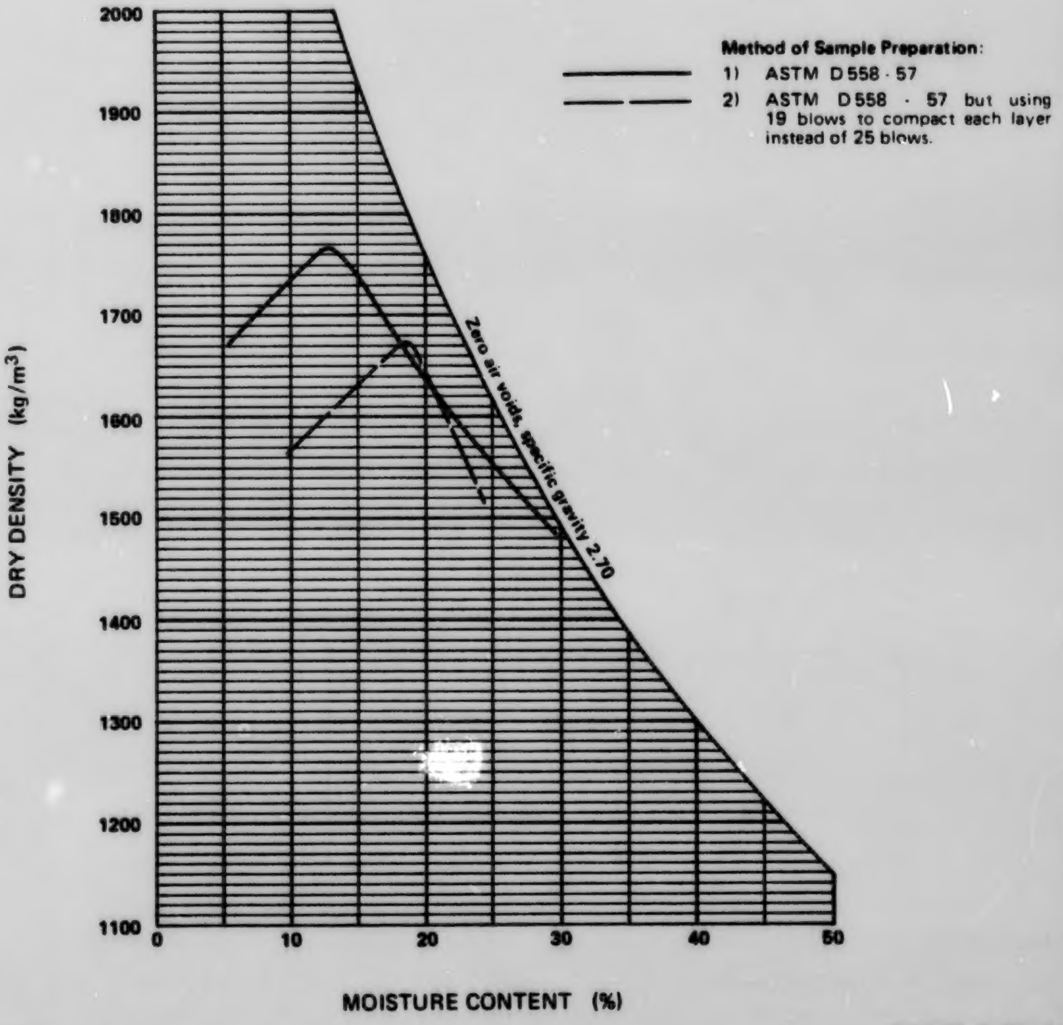
Stabilizer Dosage: FUJIBETON ______ %

Sample: Calgary: Airport

FLYASH 2 %

Sand 27 %, Silt 48 %, Clay 25 %

CEMENT ______ %



SHEET 2 OF 2

EBA Engineering Consultants Ltd.

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1SD83 - 00026

Project No.: 314 - 1264.02

Stabilizer Dosage: FUJIBETON ____ %

FLYASH 6 %

CEMENT ____ %

Sample: Calgary: Airport

Sand 27%, Silt 48%, Clay 25%

TEST DATA:

1) Method of Sample Preparation: ASTM D 558 - 57

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	5.4	1666
2	11.3	1696
3	16.1	1718
4	22.4	1548
5		

Design Field Optimum Moisture Content: 14.0 %

Design Field Maximum Dry Density: 1747 kg/m³

2) Method of Sample Preparation: ASTM D558 - 57, but using 19 blows to compact each layer instead of 25 blows

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	15.4	1646
2	10.4	1612
3	21.1	1610
4	23.3	1527
5		

Design Field Optimum Moisture Content: 17.5 %

Design Field Maximum Dry Density: 1663 kg/m³

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

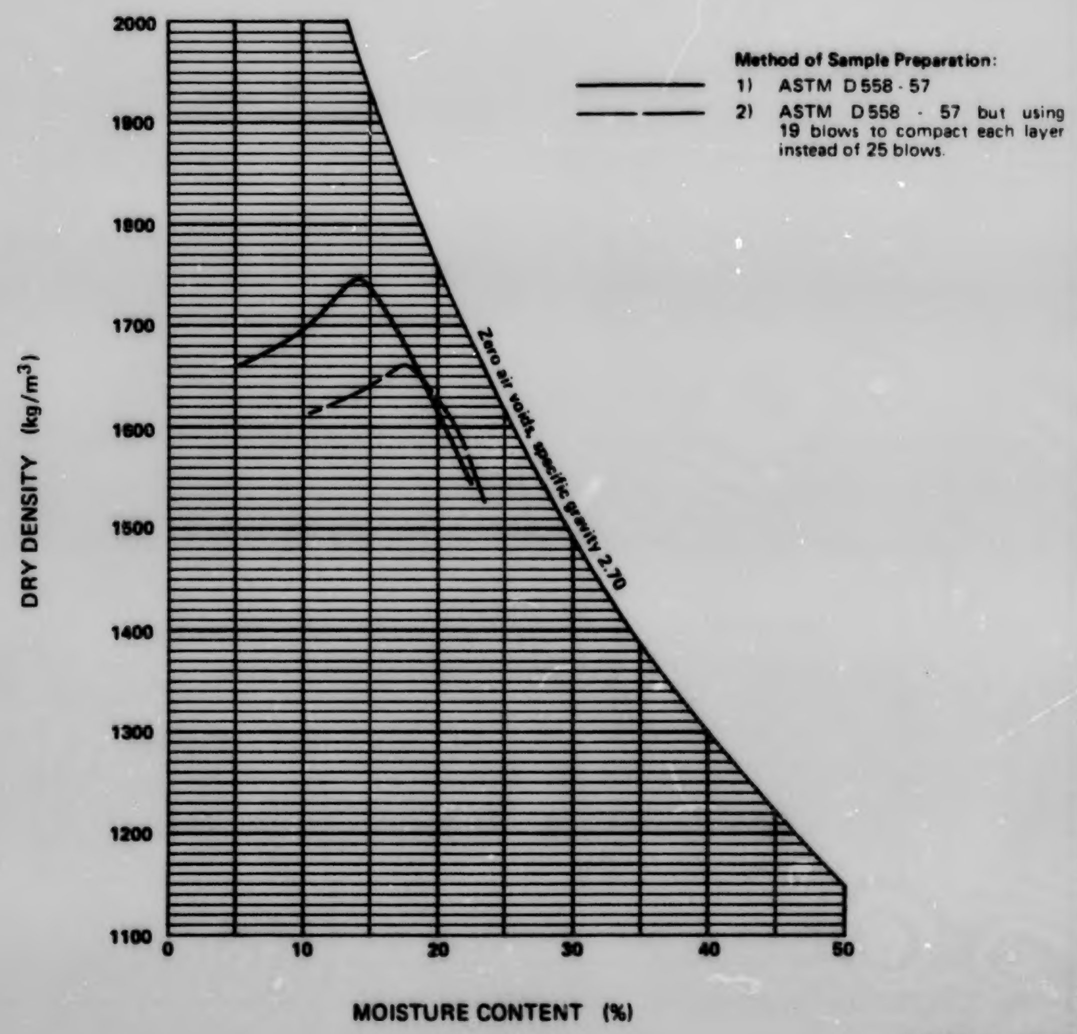
Stabilizer Dosage: FUJIBETON ______ %

FLYASH 6 %

CEMENT ______ %

Sample: Calgary: Airport

Sand 27 %, Silt 48 %, Clay 25 %



SHEET 2 OF 2

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1SD83 - 00026

Project No.: 314 - 1264.02

Stabilizer Dosage: FUJIBETON ____ %

Sample: Calgary: Airport

FLYASH 10 %

Sand 27%, Silt 48%, Clay 25%

CEMENT ____ %

TEST DATA:

1) Method of Sample Preparation: ASTM D 558 - 57

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	6.5	1664
2	9.4	1715
3	14.9	1729
4	20.5	1613
5		

Design Field Optimum Moisture Content: 12.7 %

Design Field Maximum Dry Density: 1755 kg/m³

2) Method of Sample Preparation: ASTM D558 - 57, but using 19 blows to compact each layer instead of 25 blows

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	15.0	1651
2	9.8	1627
3	20.0	1639
4	23.1	1500
5		

Design Field Optimum Moisture Content: 18.5 %

Design Field Maximum Dry Density: 1669 kg/m³

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

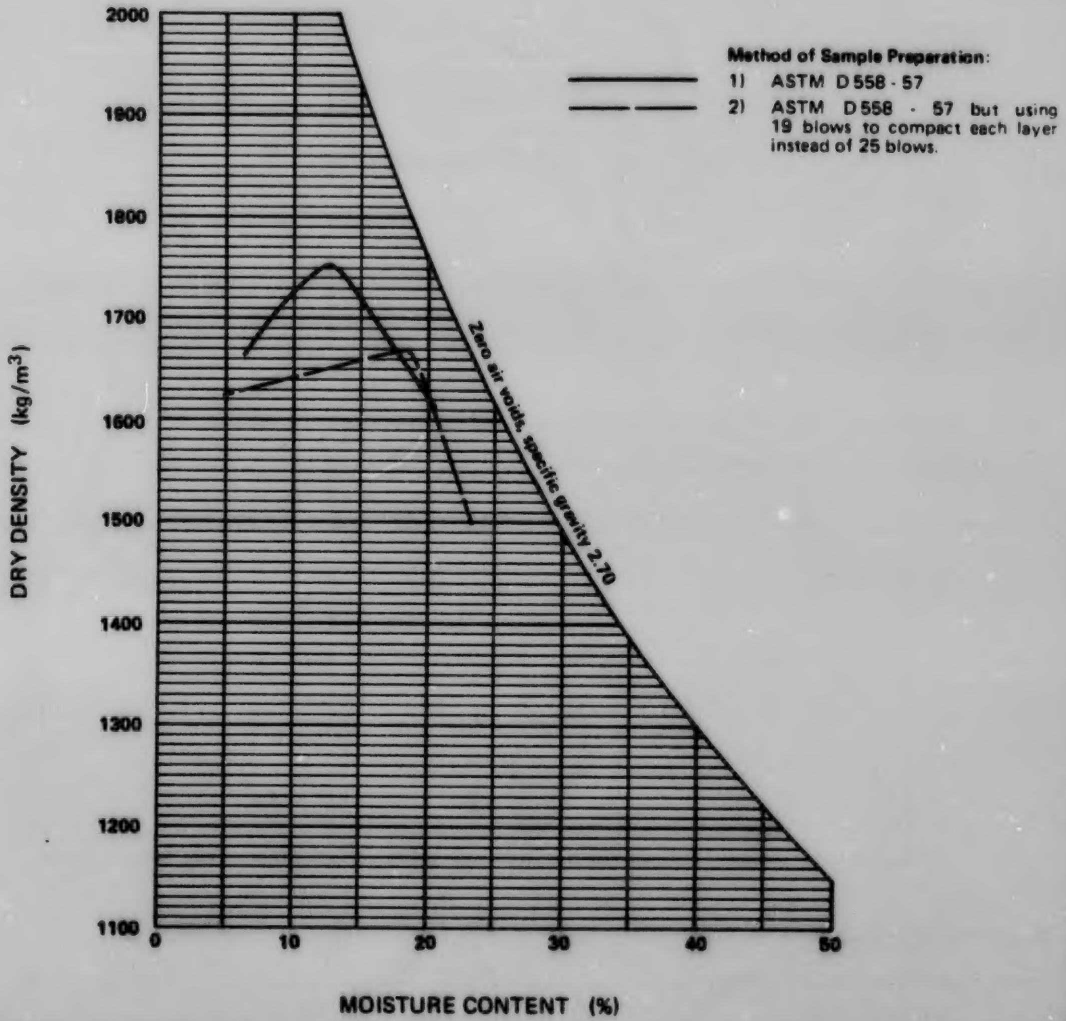
Stabilizer Dosage: FUJIBETON ______ %

Sample: Calgary: Airport

FLYASH 10 %

Sand 27 %, Silt 48 %, Clay 25 %

CEMENT ______ %



SHEET 2 OF 2

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1SD83 - 00026

Project No.: 314 - 1264.02

Stabilizer Dosage: FUJIBETON ____ %

FLYASH 13 %

CEMENT ____ %

Sample: Calgary: Airport

Sand 27%, Silt 48%, Clay 25%

TEST DATA:

1) Method of Sample Preparation: ASTM D 558 - 57

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	5.0	1672
2	10.7	1719
3	16.4	1698
4	20.6	1597
5		

Design Field Optimum Moisture Content: 11.7 %

Design Field Maximum Dry Density: 1747 kg/m³

2) Method of Sample Preparation: ASTM D558 - 57, but using 19 blows to compact each layer instead of 25 blows

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	16.6	1654
2	10.3	1624
3	20.1	1611
4	23.2	1503
5		

Design Field Optimum Moisture Content: 17.7 %

Design Field Maximum Dry Density: 1660 kg/m³

SHEET 1 OF 2

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

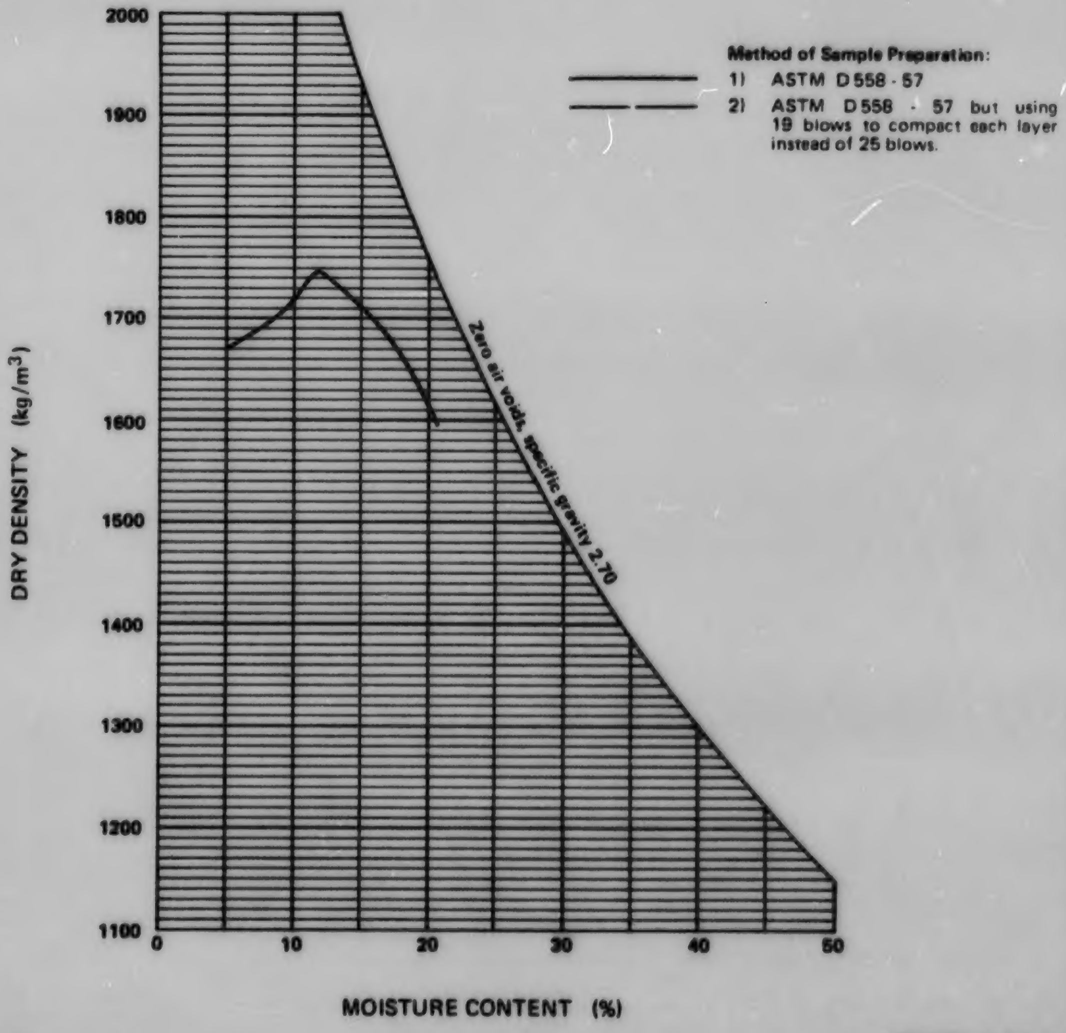
Stabilizer Dosage: FUJIBETON ____ %

Sample: Calgary: Airport

FLYASH 13 %

Sand 27 %, Silt 48 %, Clay 25 %

CEMENT ____ %



DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1SD83 - 00026

Project No.: 314 - 1264.02

Stabilizer Dosage: FUJIBETON ___ %

Sample: Calgary: Airport

Sand 27%, Silt 48%, Clay 25%

FLYASH 5 %

CEMENT 3 %

TEST DATA:

1) Method of Sample Preparation: ASTM D 558 - 57

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	9.3	1675
2	14.6	1730
3	20.5	1647
4	24.5	1533
5		

Design Field Optimum Moisture Content: 16.0 %

Design Field Maximum Dry Density: 1745 kg/m³

2) Method of Sample Preparation: ASTM D558 - 57, but using 19 blows to compact each layer instead of 25 blows

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	9.6	1643
2	14.1	1709
3	20.2	1639
4	27.1	1457
5		

Design Field Optimum Moisture Content: 15.6 %

Design Field Maximum Dry Density: 1726 kg/m³

SHEET 1 OF 2

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

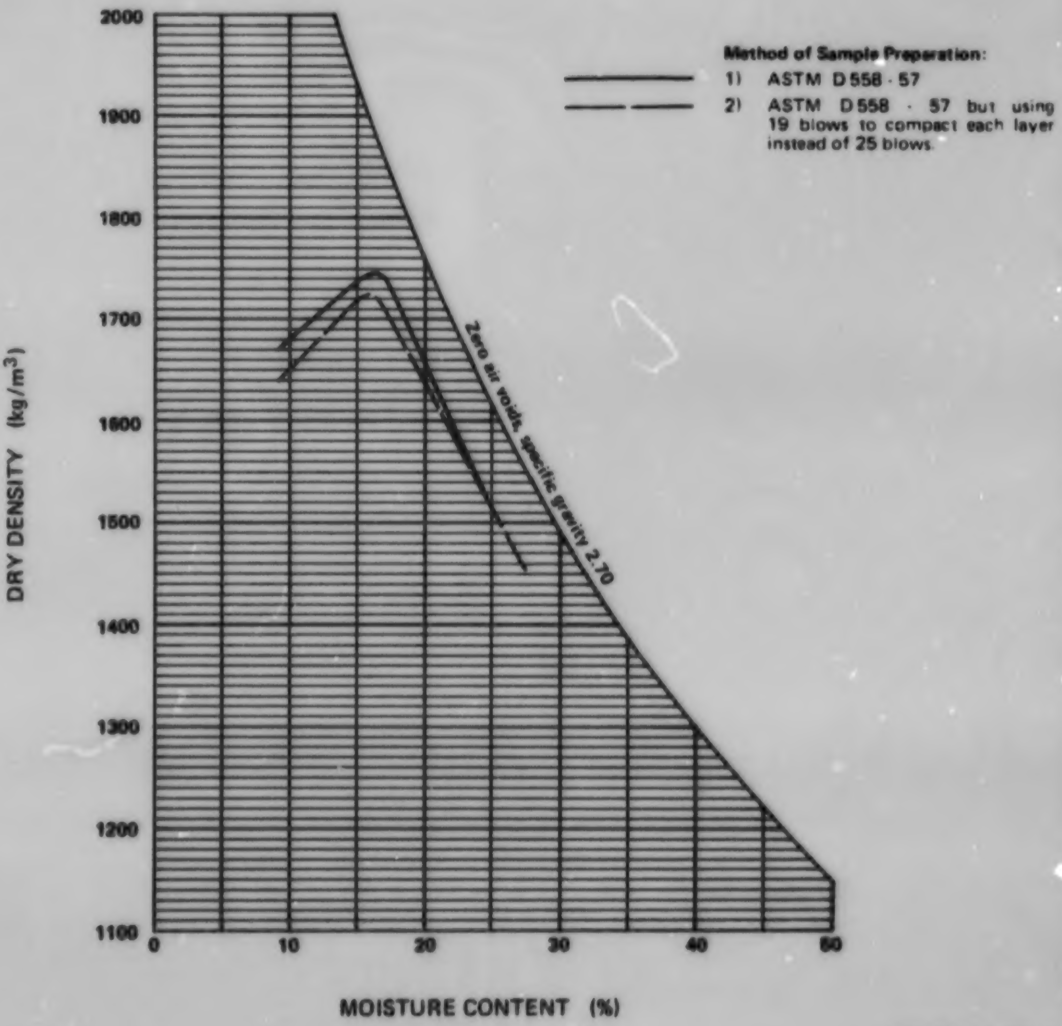
Stabilizer Dosage: FUJIBETON ____ %

FLYASH 5 %

CEMENT 3 %

Sample: Calgary: Airport

Sand 27 %, Silt 48 %, Clay 25 %



SHEET 2 OF 2

CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Calgary: Airport

Sand 27%, Silt 48%, Clay 25%

Initial Dry Density: 1758 kg/m^3

Initial Moisture Content: 10.0%

Stabilizer Dosage: FUJIBETON 1 %

Final Moisture Content: 22.3%

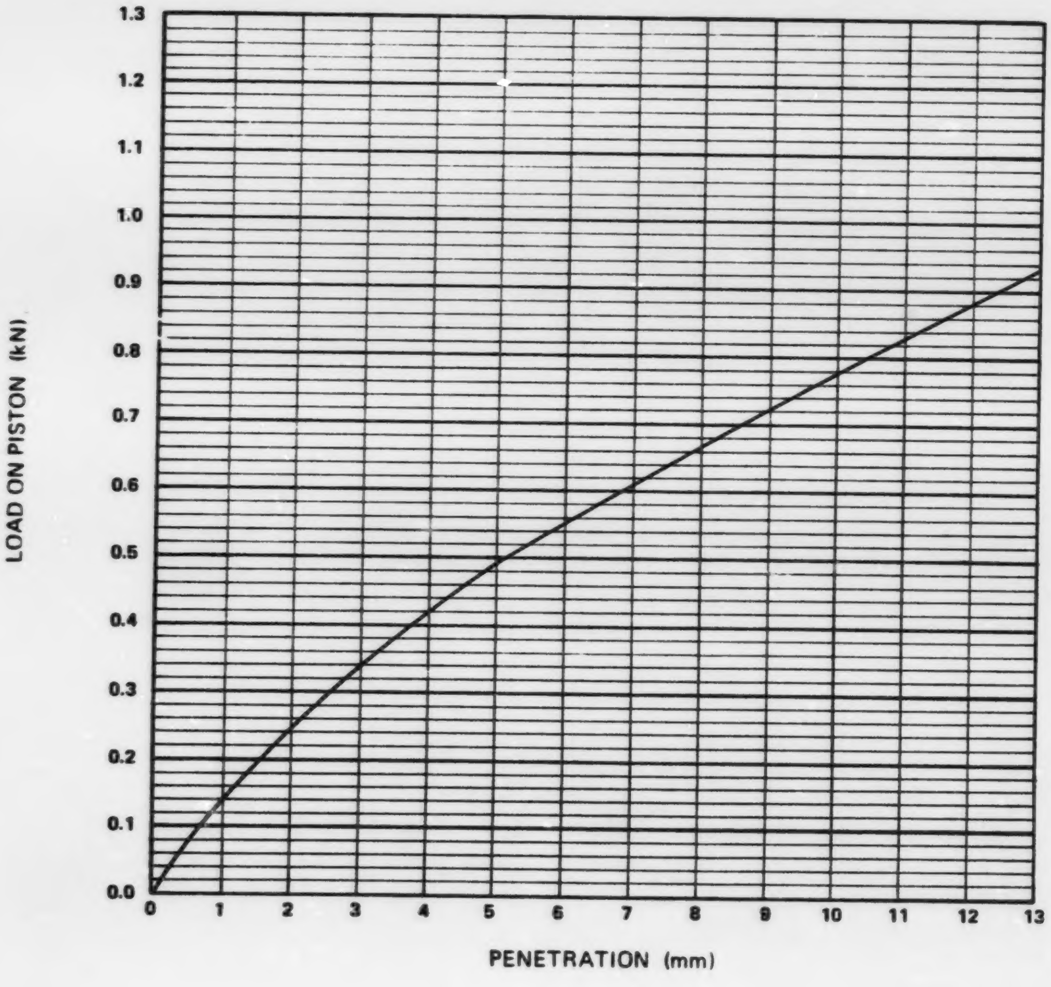
FLYASH %

California Bearing Ratio: 2.5 mm 2.2%

CEMENT %

5.0 mm 2.5%

Sample statically compacted to maximum dry density obtained during compaction test performed using 100% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Calgary: Airport

Sand 27% , Silt 48% , Clay 25%

Initial Dry Density: 1661 kg/m^3

Initial Moisture Content: 18.7 %

Stabilizer Dosage: FUJIBETON 1 %

Final Moisture Content: 23.5 %

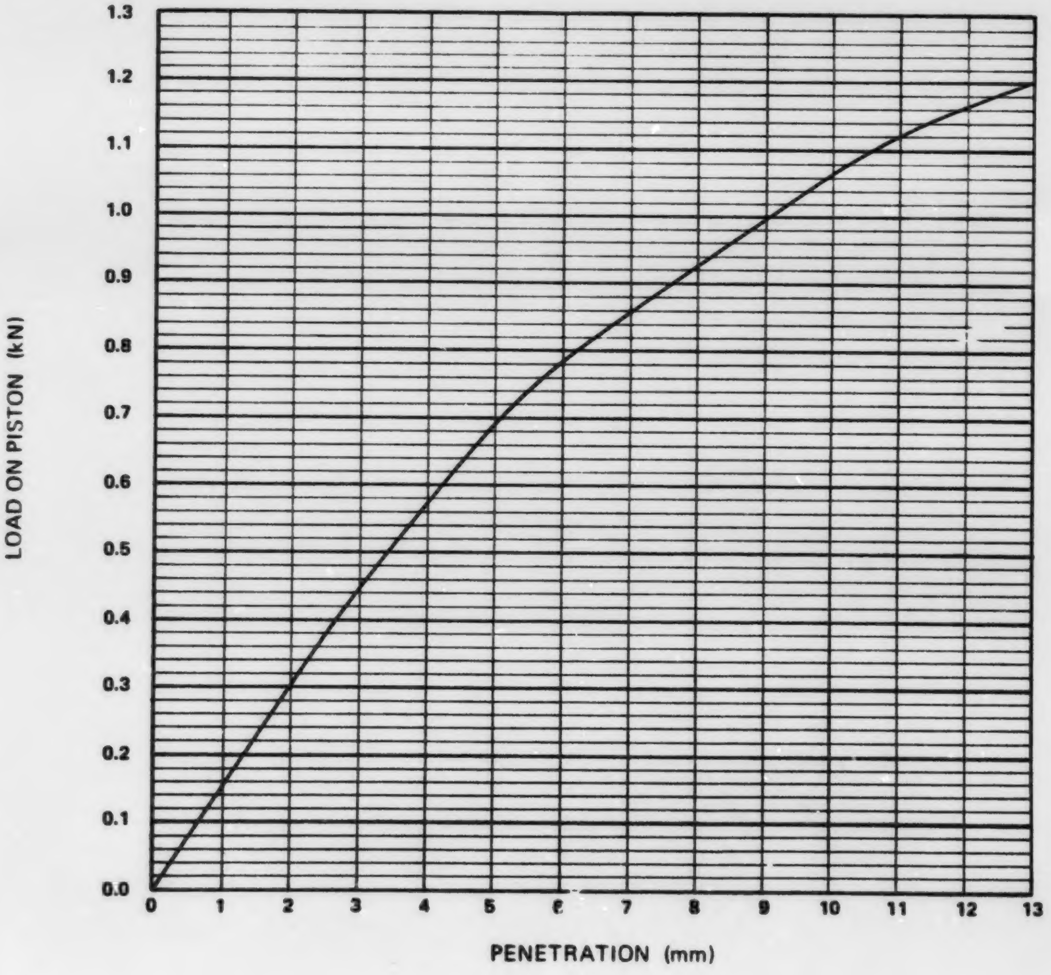
FLYASH %

California Bearing Ratio: 2.5 mm 3.0%

CEMENT %

5.0 mm 3.5%

Sample statically compacted to maximum dry density obtained during compaction test performed using 75% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Calgary: Airport

Sand 27%, Silt 48%, Clay 25%

Initial Dry Density: 1634 kg/m^3

Initial Moisture Content: 20.2%

Stabilizer Dosage: FUJIBETON 2 %

Final Moisture Content: 20.2%

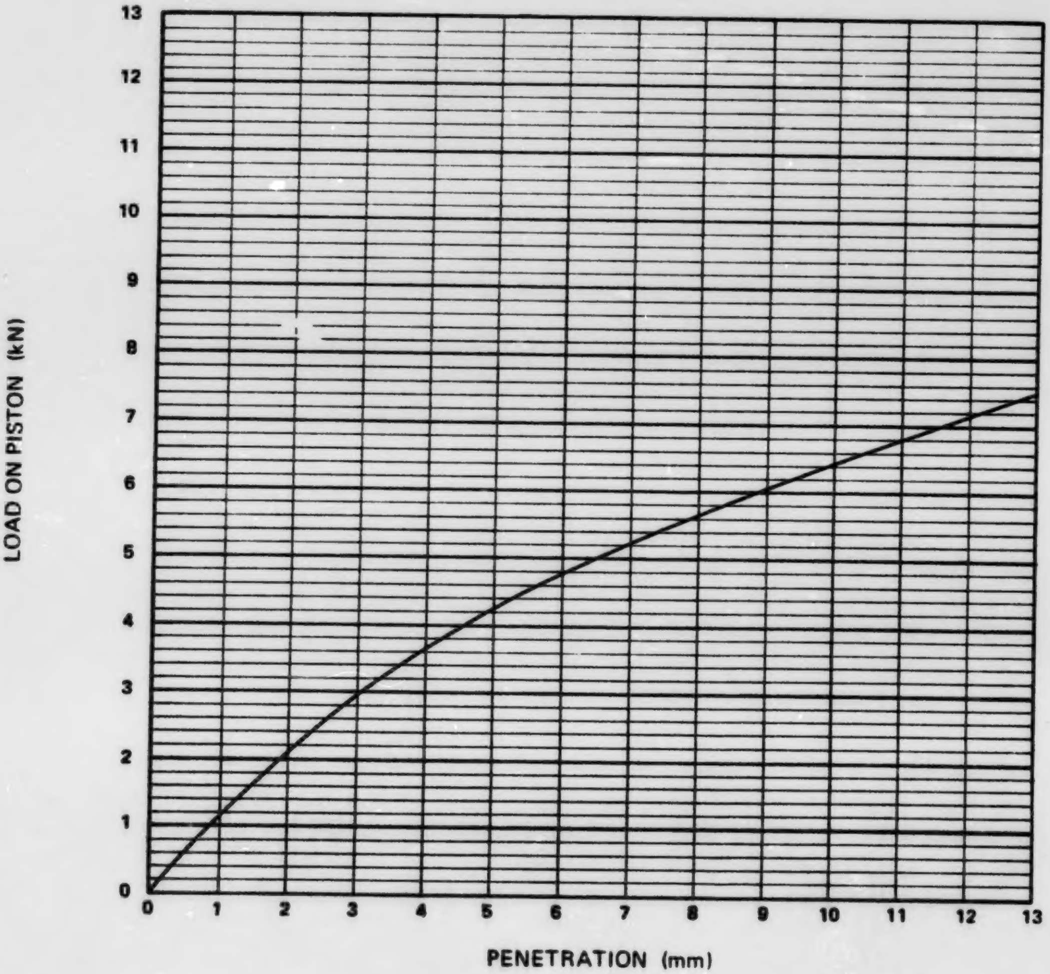
FLYASH %

California Bearing Ratio: 2.5 mm 19%

CEMENT %

5.0 mm 21%

Sample statically compacted to maximum dry density obtained during compaction test performed using 100% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Calgary: Airport

Sand 27% , Silt 48% , Clay 25%

Initial Dry Density: 1682 kg/m^3

Initial Moisture Content: 18.1%

Stabilizer Dosage: FUJIBETON 2 %

Final Moisture Content: 24.5%

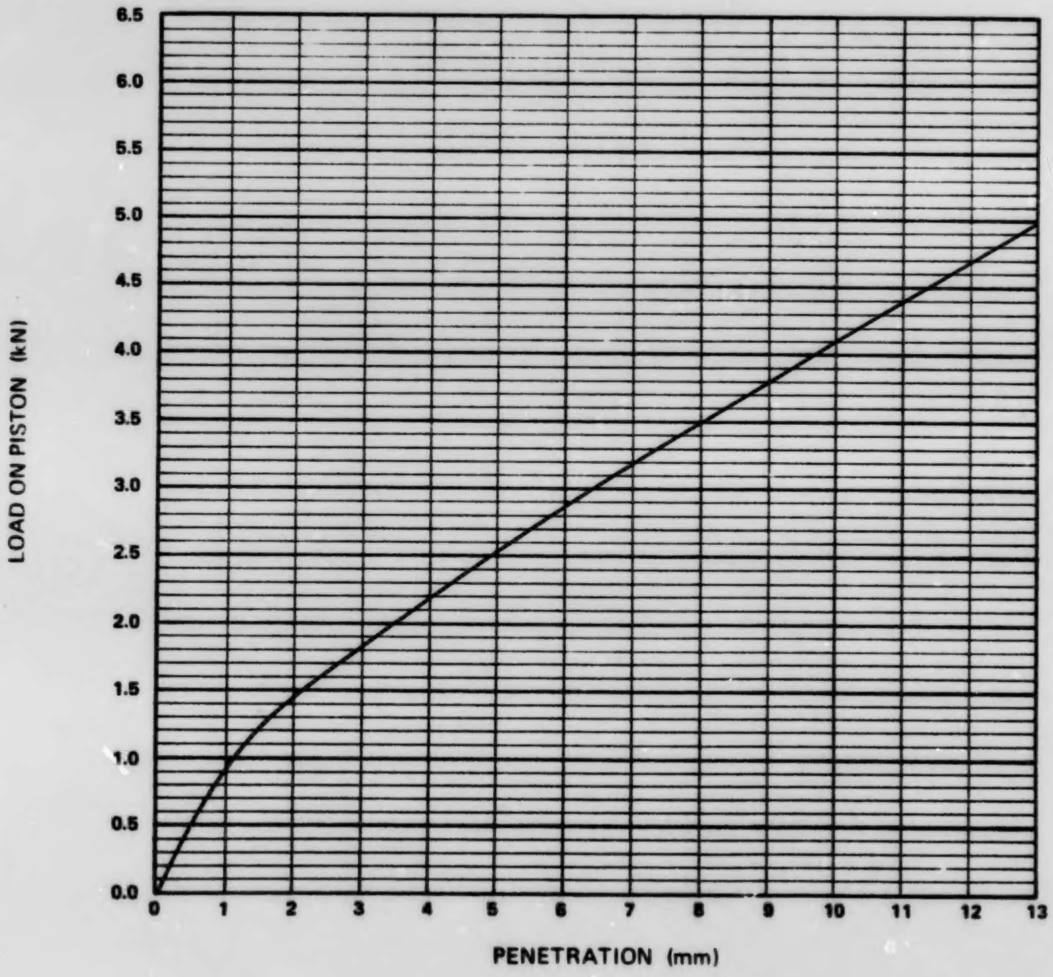
FLYASH %

California Bearing Ratio: 2.5 mm 12.7%

CEMENT %

5.0 mm 13.0%

Sample statically compacted to maximum dry density obtained during compaction test performed using 75% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Calgary: Airport

Sand 27% , Silt 48% , Clay 25%

Initial Dry Density: 1704 kg/m^3

Initial Moisture Content: 17.3%

Stabilizer Dosage: FUJIBETON 4 %

FLYASH %

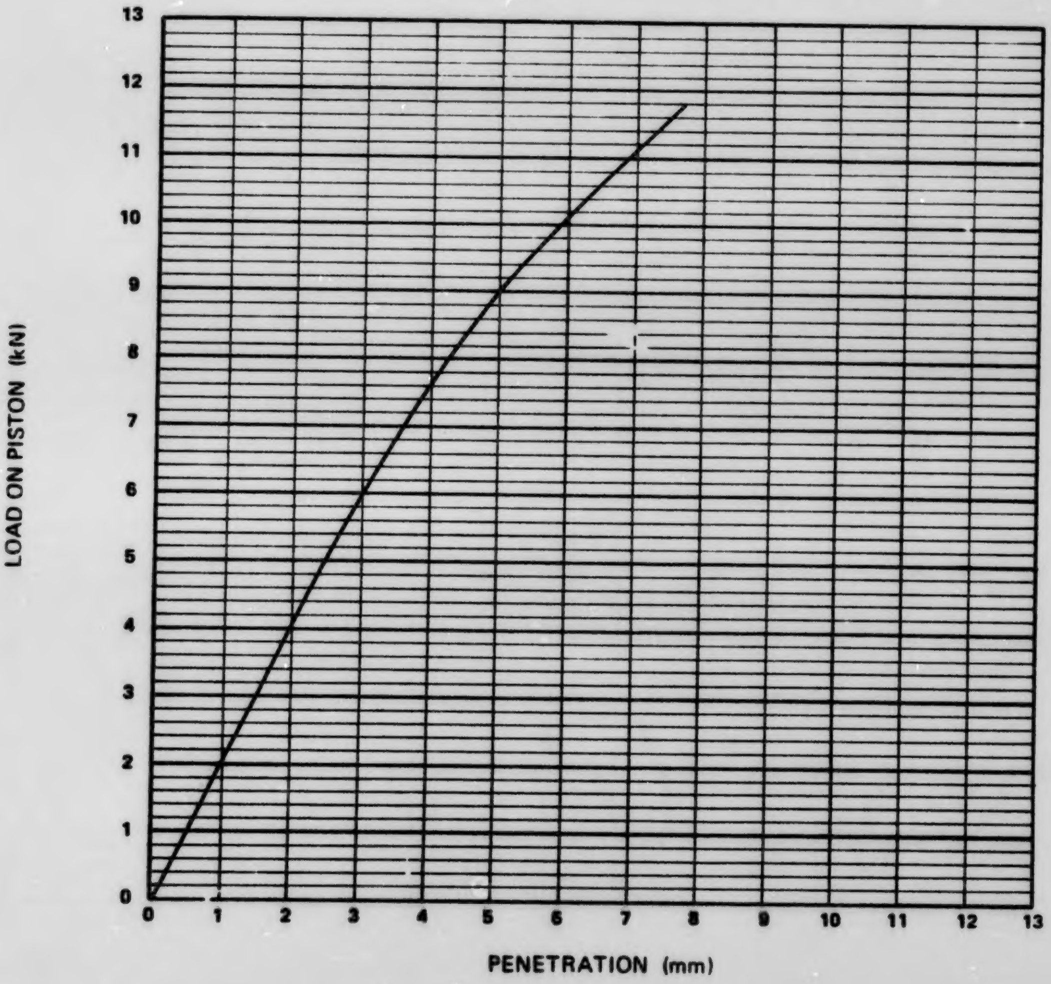
CEMENT %

Final Moisture Content: 22.0%

California Bearing Ratio: 2.5 mm 40%

5.0 mm 45%

Sample statically compacted to maximum dry density obtained during compaction test performed using 100% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Calgary: Airport

Sand 27% , Silt 48% , Clay 25%

Initial Dry Density: 1765 kg/m^3

Initial Moisture Content: 18.4 %

Stabilizer Dosage: FUJIBETON 4 %

Final Moisture Content: 19.1 %

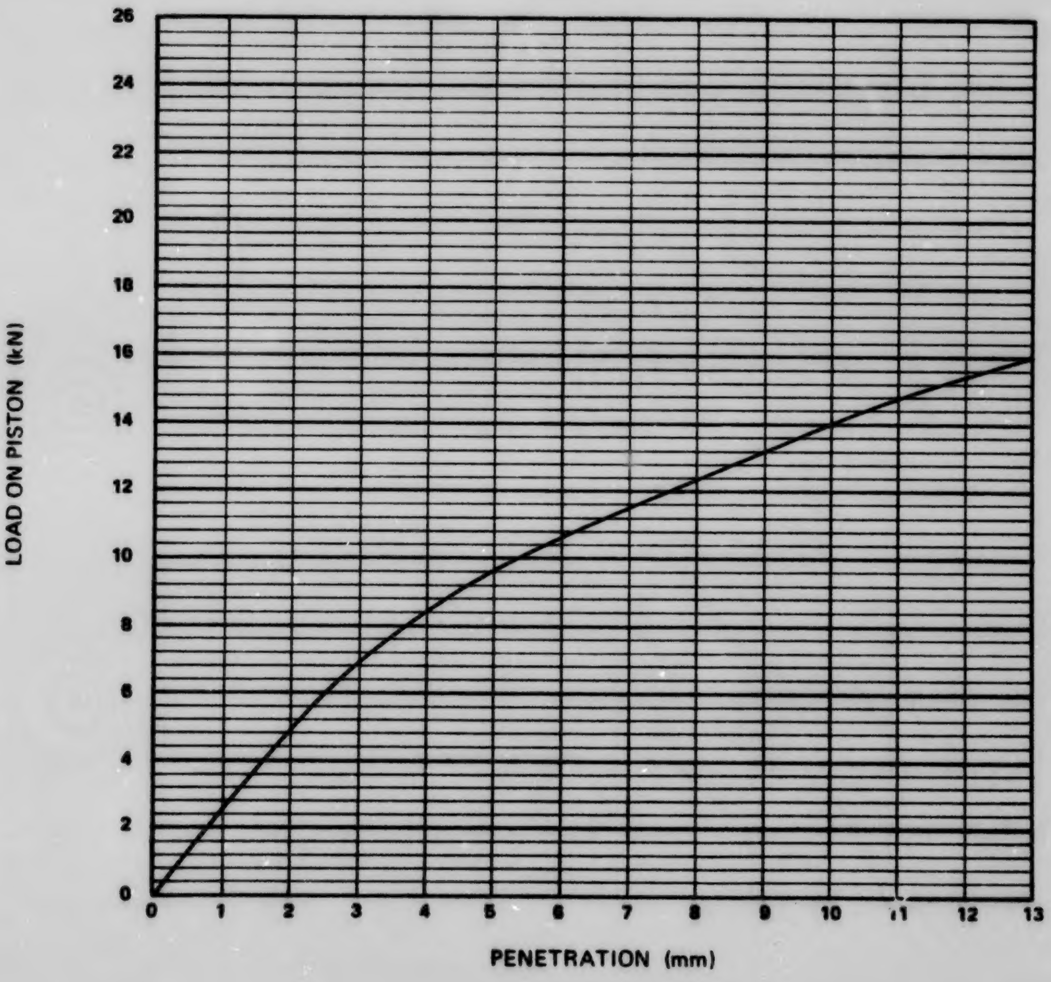
FLYASH %

California Bearing Ratio: 2.5 mm 46 %

CEMENT %

5.0 mm 48 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 75% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Calgary: Airport

Sand 27%, Silt 48%, Clay 25%

Initial Dry Density: 1673 kg/m^3

Initial Moisture Content: 20.1 %

Stabilizer Dosage: FUJIBETON 6 %

FLYASH %

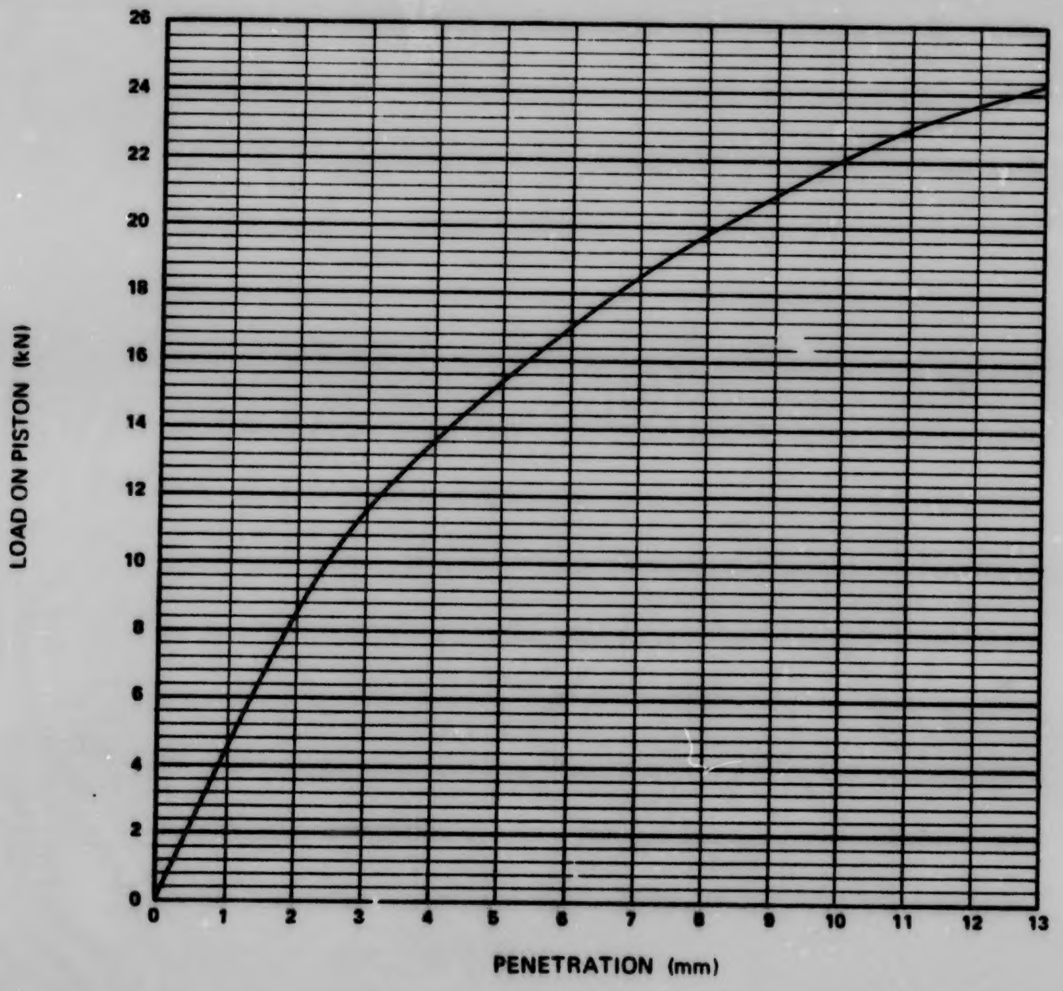
CEMENT %

Final Moisture Content: 18.4 %

California Bearing Ratio: 2.5 mm 80 %

5.0 mm 78 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 100% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Calgary: Airport

Sand 27%, Silt 48%, Clay 25%

Initial Dry Density: 1656 kg/m^3

Initial Moisture Content: 19.1%

Stabilizer Dosage: FUJIBETON 6 %

FLYASH %

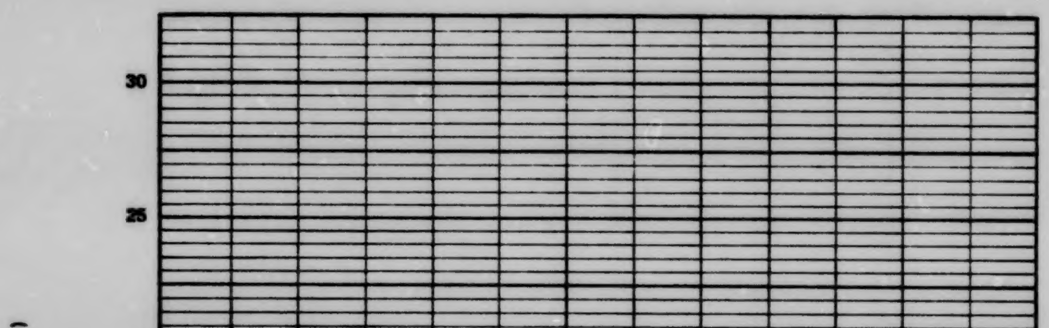
CEMENT %

Final Moisture Content: 19.6%

California Bearing Ratio: 2.5 mm 62%

5.0 mm 60%

Sample statically compacted to maximum dry density obtained during compaction test performed using 75% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Calgary: Airport

Sand 27%, Silt 48%, Clay 25%

Initial Dry Density: 1722 kg/m^3

Initial Moisture Content: 17.5 %

Stabilizer Dosage: FUJIBETON 10 %

Final Moisture Content: 17.9 %

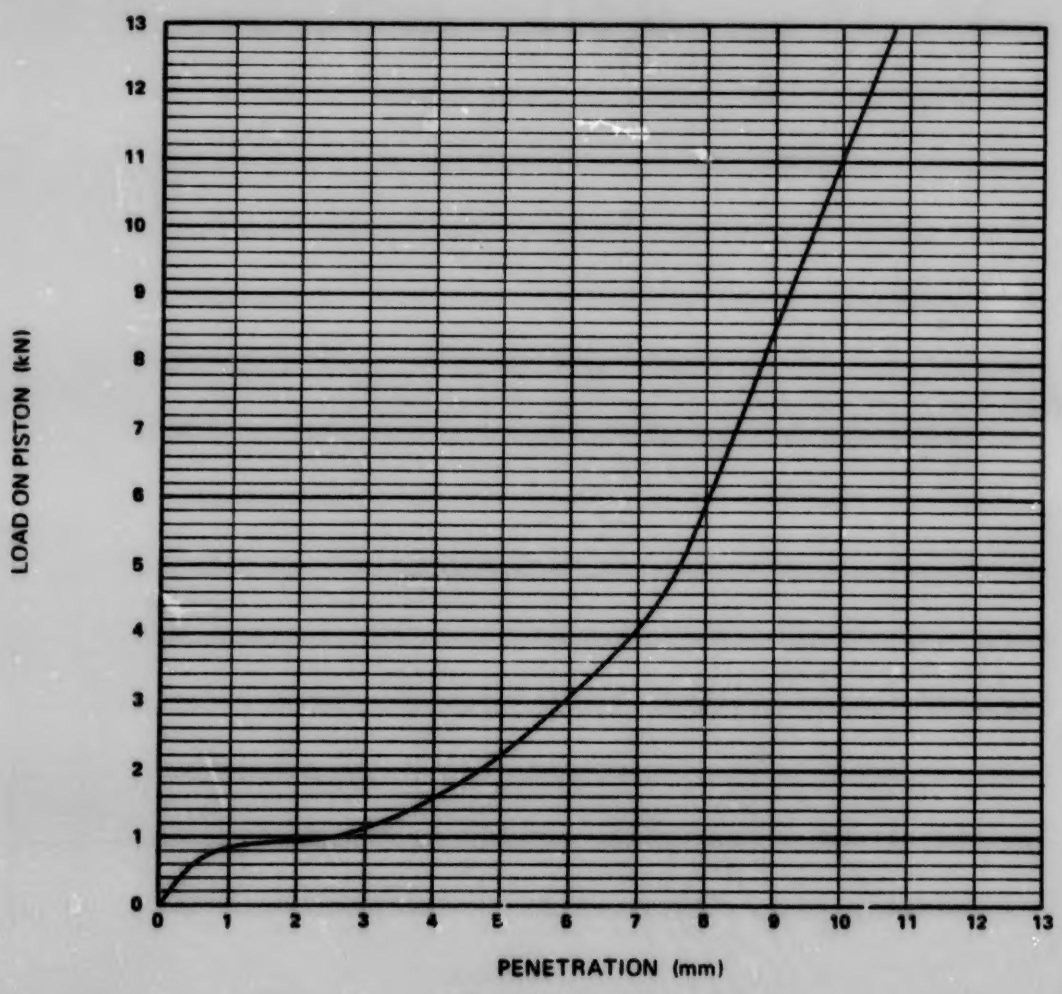
FLYASH %

California Bearing Ratio: 2.5 mm

CEMENT %

5.0 mm

Sample statically compacted to maximum dry density obtained during compaction test performed using 100% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Calgary: Airport

Sand 27% , Silt 48% , Clay 25%

Initial Dry Density: 1729 kg/m^3

Initial Moisture Content: 18.6 %

Stabilizer Dosage: FUJIBETON 10 %

FLYASH %

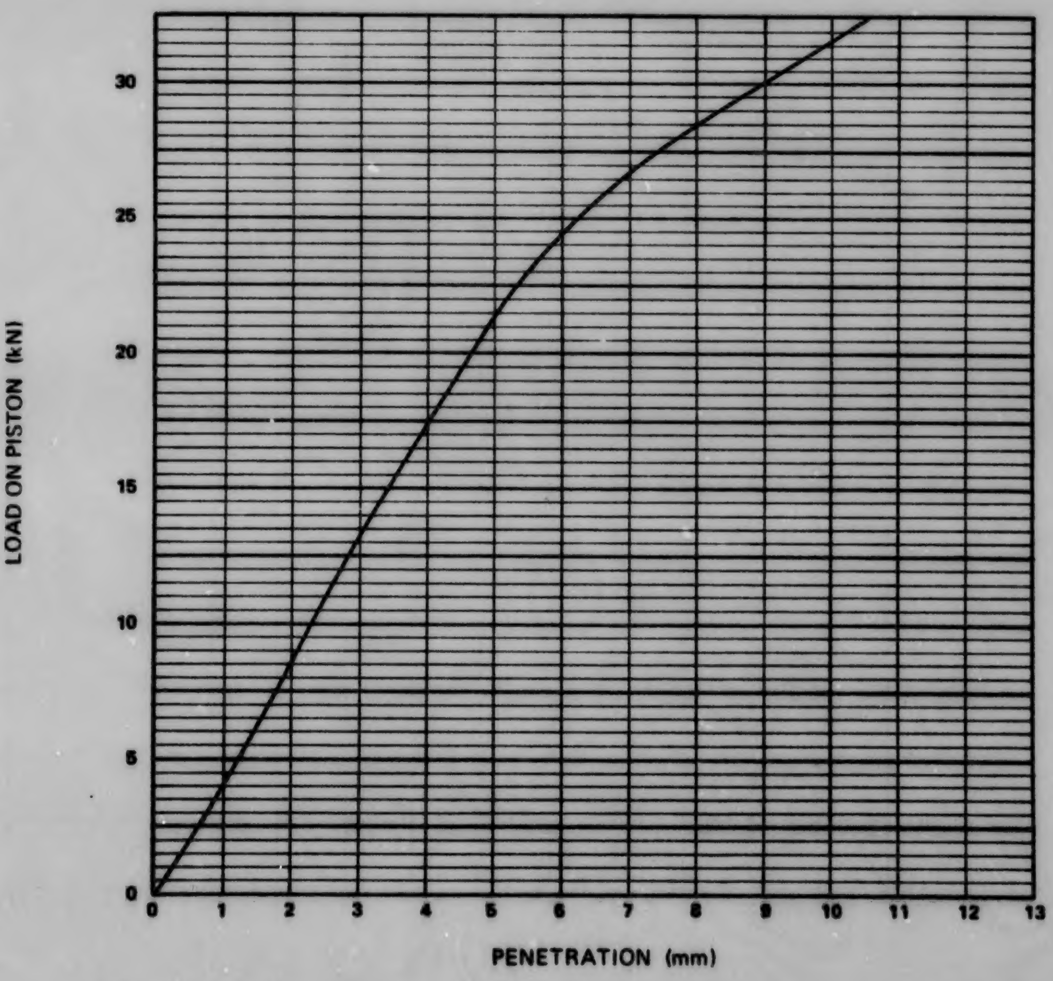
CEMENT %

Final Moisture Content: 18.4 %

California Bearing Ratio: 2.5 mm 89 %

5.0 mm 109 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 75% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



EBA Engineering Consultants Ltd.

CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Calgary: Airport

Sand 27%, Silt 48%, Clay 25%

Initial Dry Density: 1759 kg/m^3

Initial Moisture Content: 13.2%

Final Moisture Content: 18.6%

Stabilizer Dosage: FUJIBETON ____ %

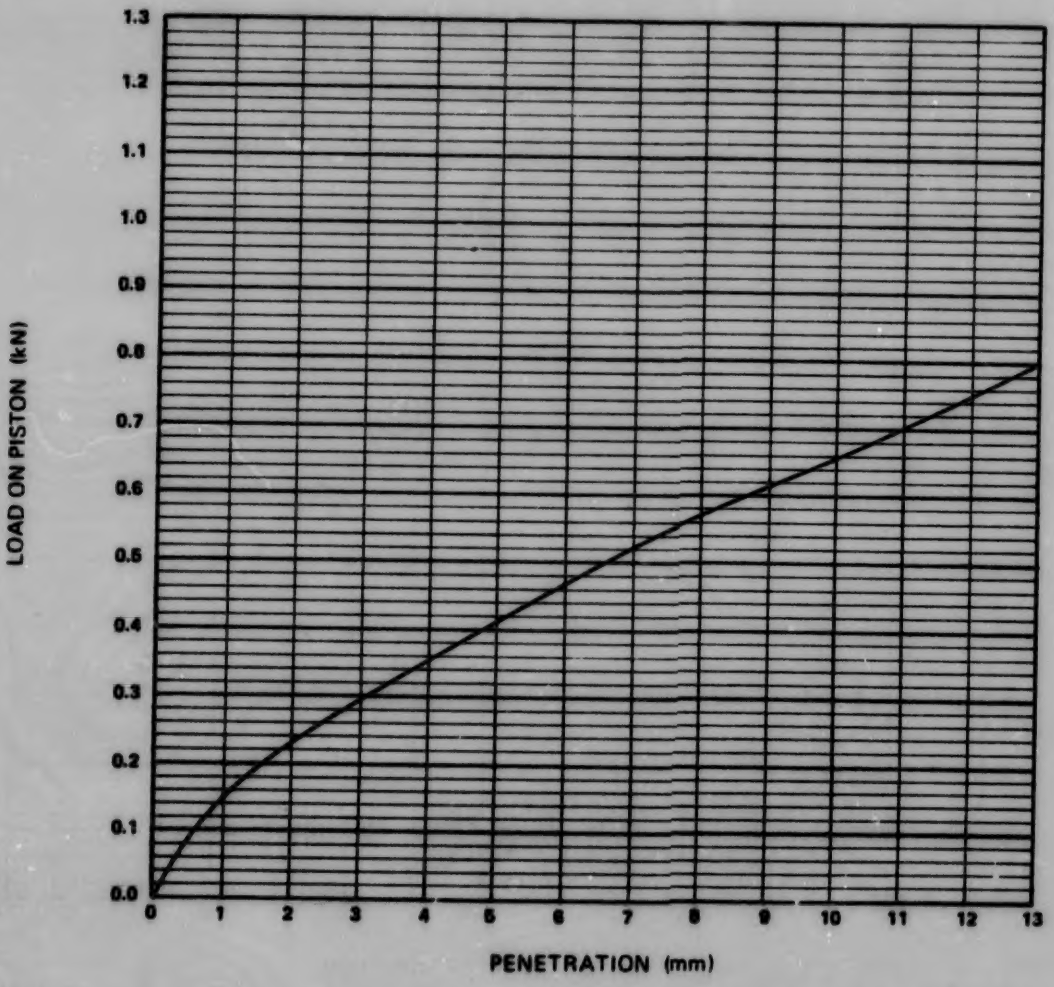
FLYASH 2 %

CEMENT ____ %

California Bearing Ratio: 2.5 mm 2.0%

5.0 mm 2.1%

Sample statically compacted to maximum dry density obtained during compaction test performed using 100% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Calgary: Airport

Sand 27% , Silt 48% , Clay 25%

Initial Dry Density: 1655 kg/m^3

Initial Moisture Content: 19.9 %

Stabilizer Dosage: FUJIBETON ____ %

FLYASH 2 %

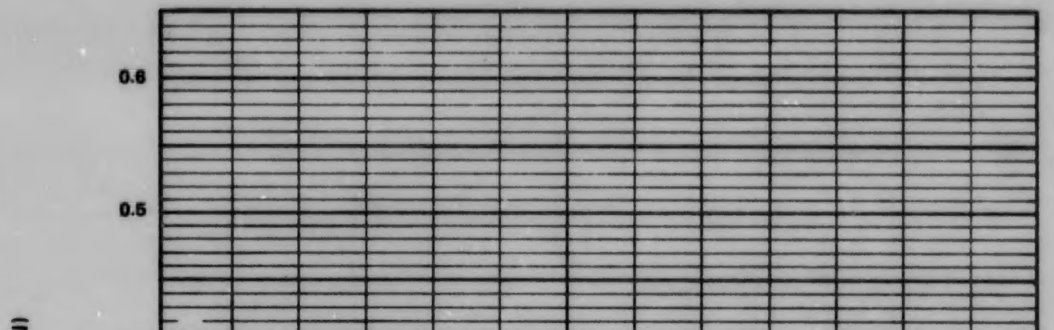
CEMENT ____ %

Final Moisture Content: 21.4 %

California Bearing Ratio: 2.5 mm 1.6 %

5.0 mm 1.4 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 75% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Calgary: Airport

Sand 27%, Silt 48%, Clay 25%

Initial Dry Density: 1905 kg/m^3

Initial Moisture Content: 12.2%

Stabilizer Dosage: FUJIBETON ______ %

FLYASH 6 %

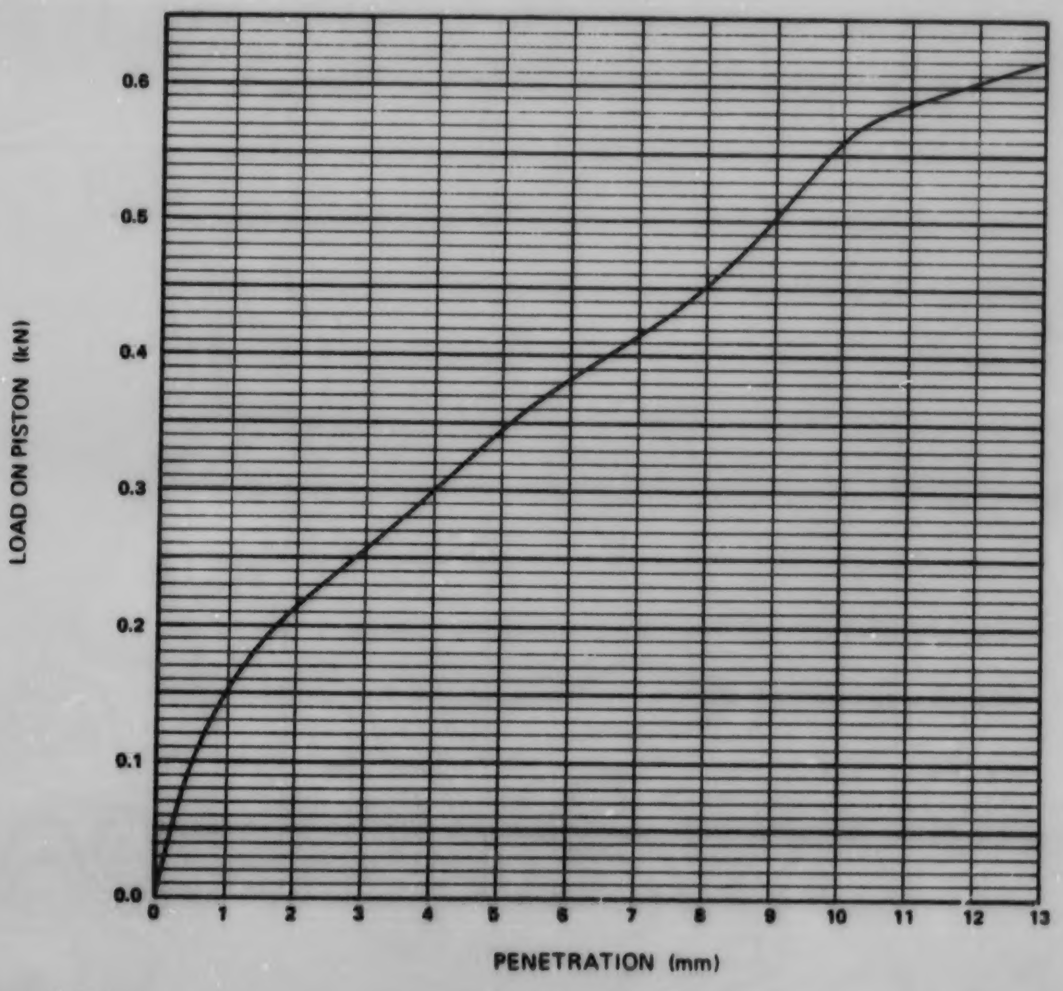
CEMENT ______ %

Final Moisture Content: 19.1%

California Bearing Ratio: 2.5 mm 1.8%

5.0 mm 1.8%

Sample statically compacted to maximum dry density obtained during compaction test performed using 100% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Calgary: Airport

Sand 27%, Silt 48%, Clay 25%

Initial Dry Density: 1644 kg/m^3

Initial Moisture Content: 18.9%

Stabilizer Dosage: FUJIBETON ____ %

Final Moisture Content: 20.5%

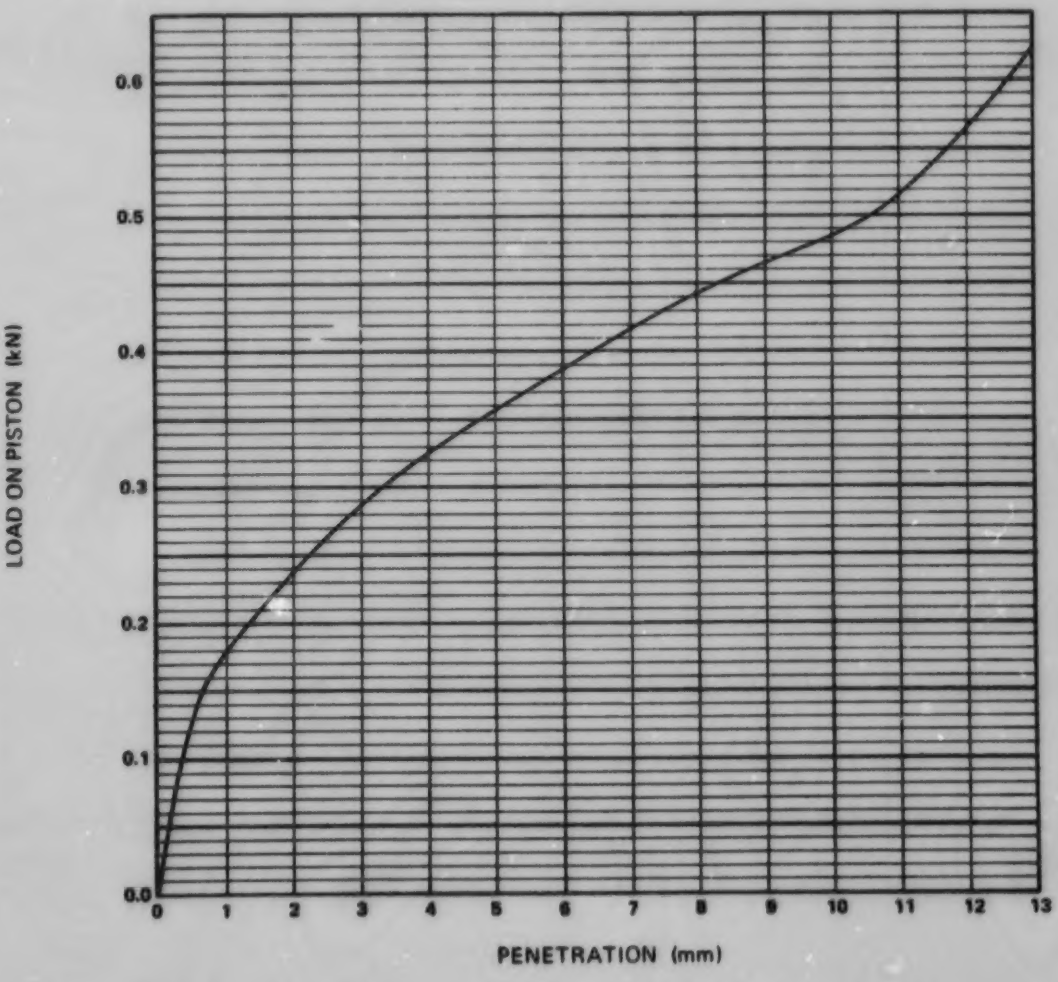
FLYASH 6 %

California Bearing Ratio: 2.5 mm 2.0%

CEMENT ____ %

5.0 mm 1.8%

Sample statically compacted to maximum dry density obtained during compaction test performed using 75% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Calgary: Airport

Sand 27%, Silt 48%, Clay 25%

Initial Dry Density: 1695 kg/m^3

Initial Moisture Content: 16.7 %

Stabilizer Dosage: FUJIBETON ______ %

FLYASH 10 %

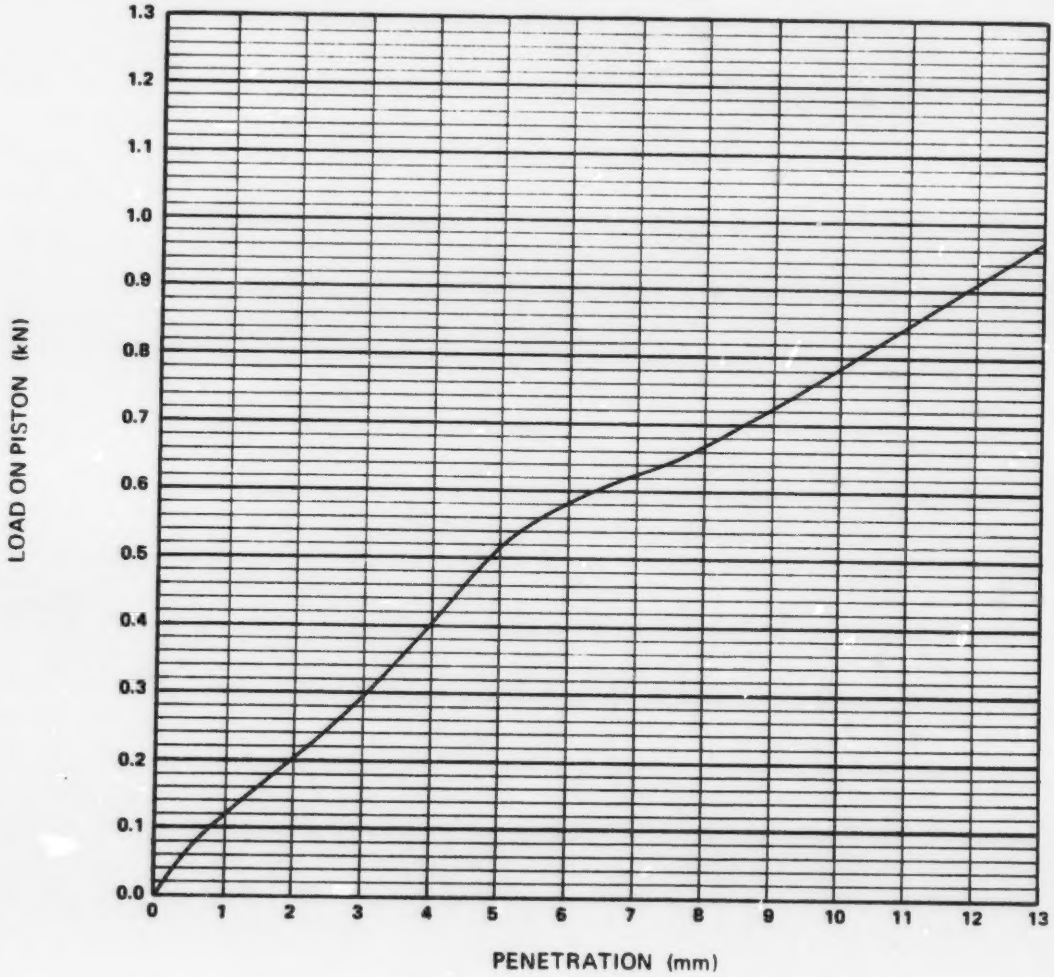
CEMENT ______ %

Final Moisture Content: 20.5 %

California Bearing Ratio: 2.5 mm 1.8 %

5.0 mm 2.6 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 100% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 · 00026

Project No.: 314 · 1264.02

Sample: Calgary: Airport

Sand 27% , Silt 48% , Clay 25%

Initial Dry Density: 1635 kg/m^3

Initial Moisture Content: 21.0%

Stabilizer Dosage: FUJIBETON ____ %

FLYASH 10 %

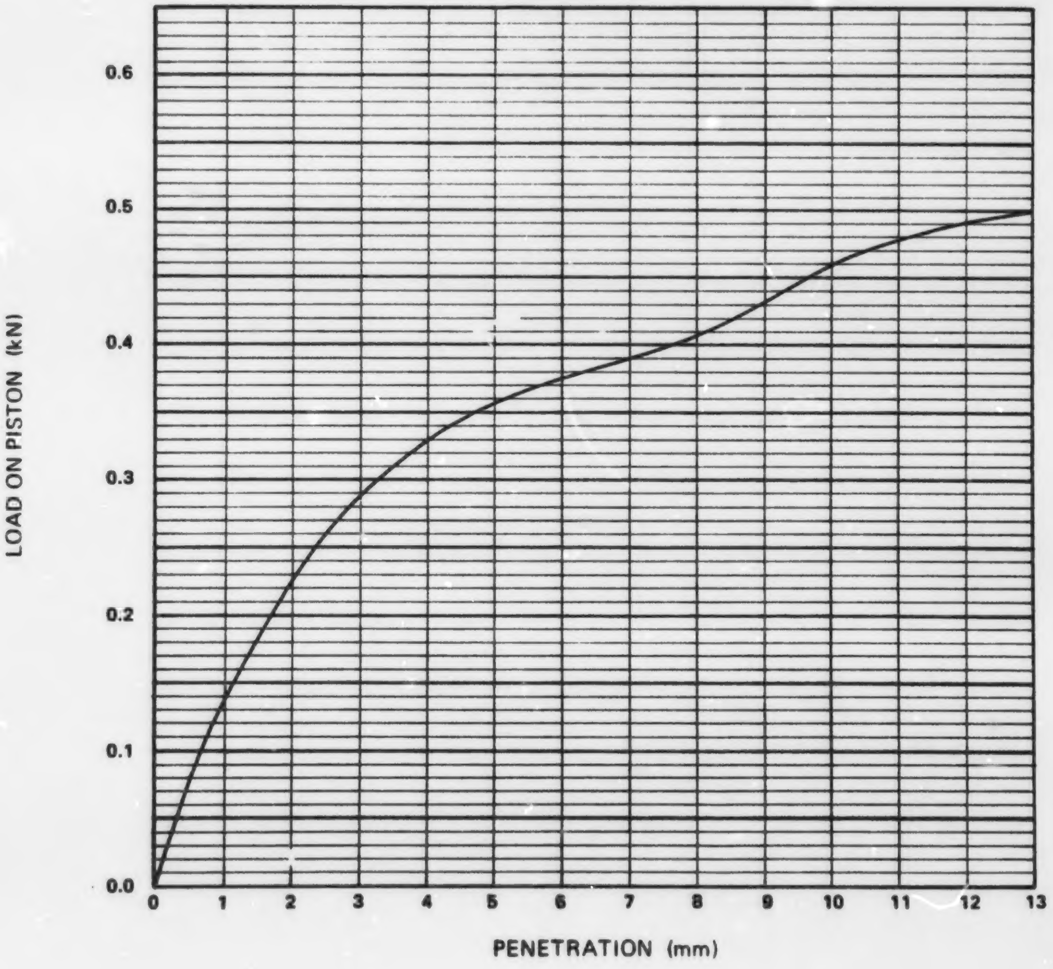
CEMENT ____ %

Final Moisture Content: 21.5%

California Bearing Ratio: 2.5 mm 2.0%

5.0 mm 1.8%

Sample statically compacted to maximum dry density obtained during compaction test performed using 75% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Calgary: Airport

Sand 27% , Silt 48% , Clay 25%

Initial Dry Density: 1689 kg/m^3

Initial Moisture Content: 15.6%

Stabilizer Dosage: FUJIBETON ______ %

FLYASH 13 %

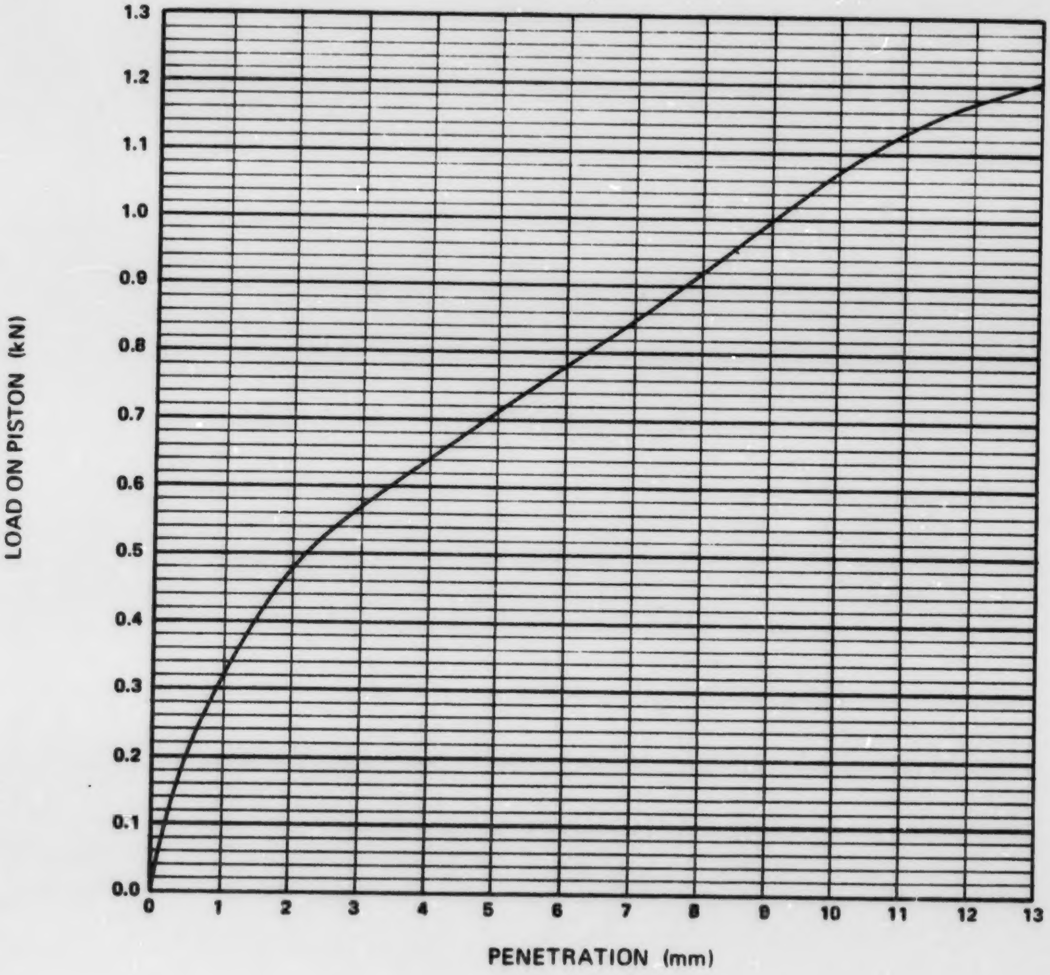
CEMENT ______ %

Final Moisture Content: 18.1%

California Bearing Ratio: 2.5 mm 4.05%

5.0 mm 3.55%

Sample statically compacted to maximum dry density obtained during compaction test performed using 100% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.

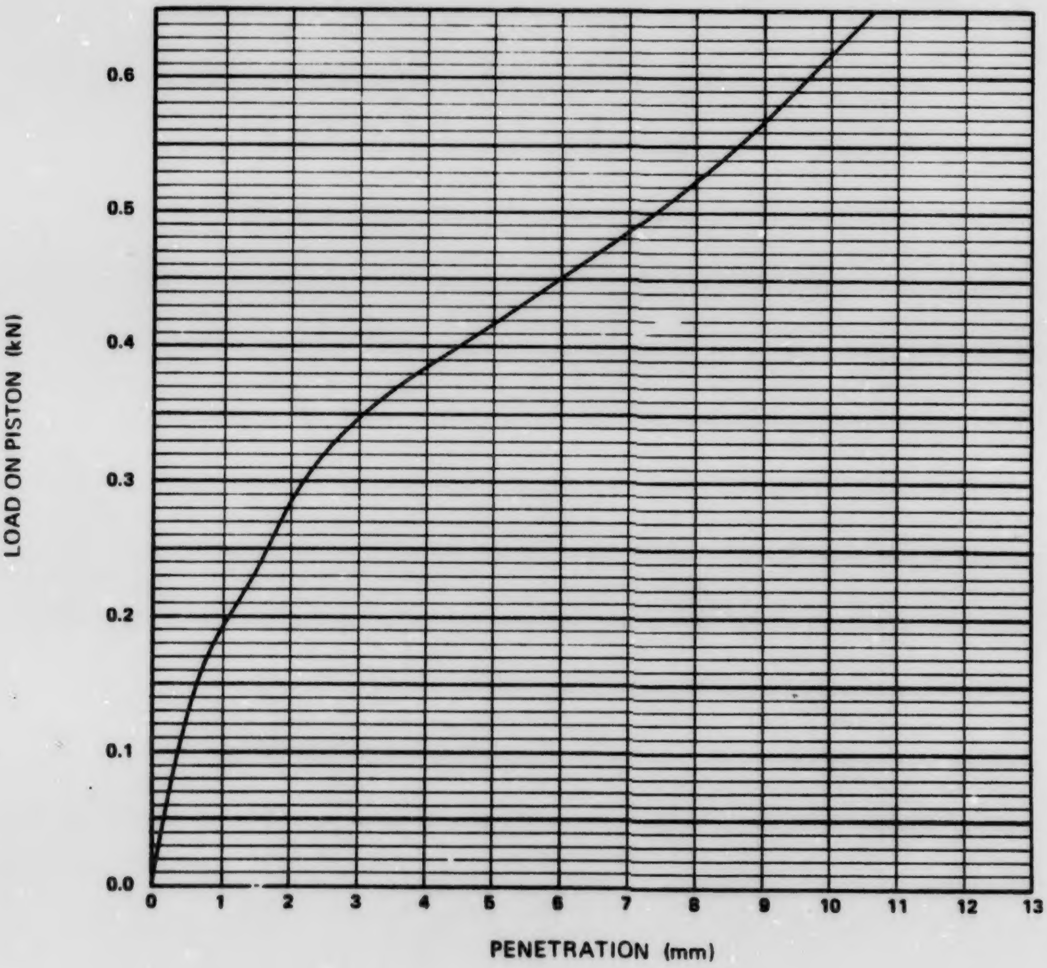


CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client:	TRANSPORT CANADA	Contract No.:	1 SD 83 - 00026
Project No.:	314 - 1264.02		
Sample:	Calgary: Airport	Initial Dry Density:	1625 kg/m^3
	Sand 27%, Silt 48%, Clay 25%	Initial Moisture Content:	20.2 %
Stabilizer Dosage:	FUJIBETON ____ %	Final Moisture Content:	20.3%
	FLYASH 13 %	California Bearing Ratio: 2.5 mm	2.5%
	CEMENT ____ %	5.0 mm	2.1%

Sample statically compacted to maximum dry density obtained during compaction test performed using 75% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Calgary: Airport

Sand 27% , Silt 48% , Clay 25%

Initial Dry Density: 1739 kg/m^3

Initial Moisture Content: 16.4%

Final Moisture Content: 18.4%

Stabilizer Dosage: FUJIBETON ______ %

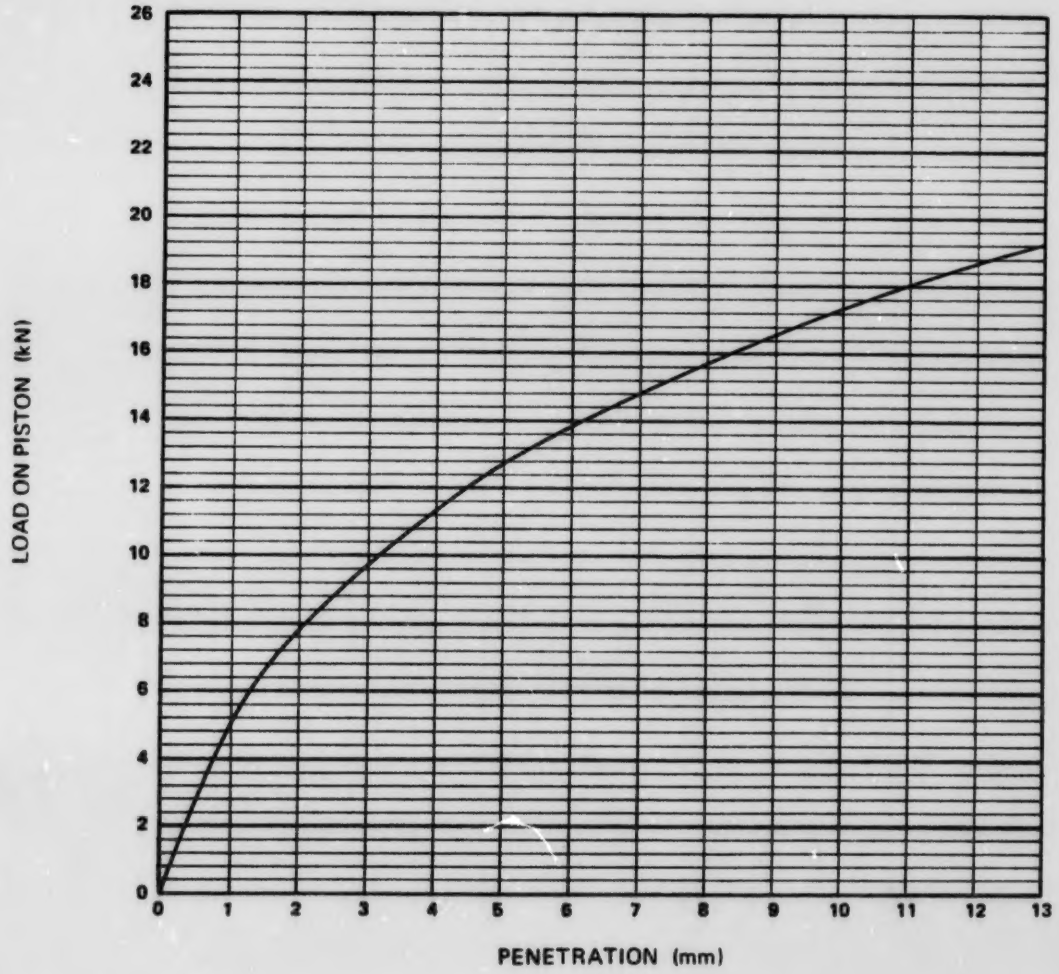
FLYASH 5 %

CEMENT 3 %

California Bearing Ratio: 2.5 mm 68%

5.0 mm 65%

Sample statically compacted to maximum dry density obtained during compaction test performed using 100% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Calgary: Airport

Sand 27% , Silt 48% , Clay 25%

Initial Dry Density: 1725.4 kg/m^3

Initial Moisture Content: 15.6 %

Stabilizer Dosage: FUJIBETON ______ %

Final Moisture Content: 18.0 %

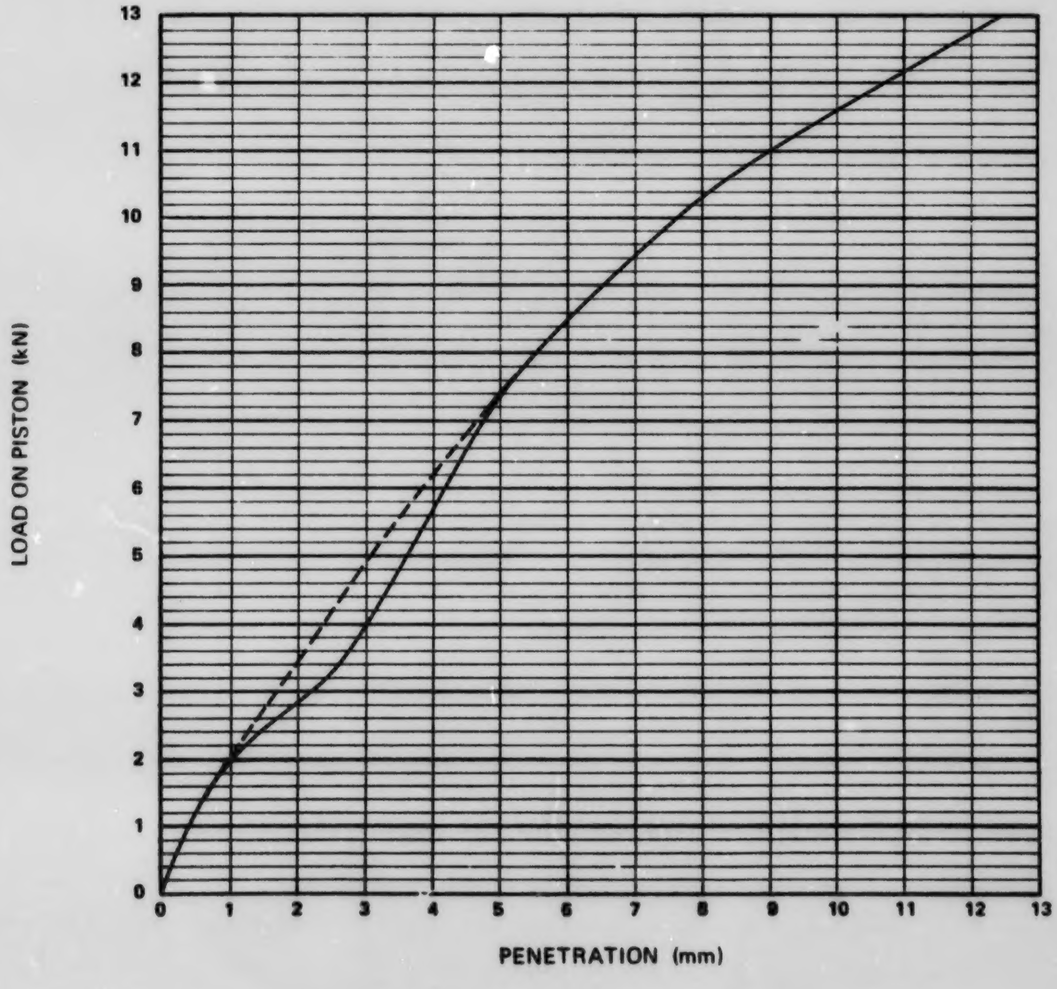
FLYASH 5 %

California Bearing Ratio: 2.5 mm 33 %

CEMENT 3 %

5.0 mm 37 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 75% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



EBA Engineering Consultants Ltd.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1747 kg/m^3

Sample: Calgary: Airport

Design Optimum Moisture Content:% 10.6 %

Sand 27 %, Silt 48 %, Clay 25 %

Initial Dry Density: 1648 kg/m^3

Initial Moisture Content: 10.8 %

Initial Volume: 916.0 cm^3

Stabilizer Dosage: FUJIBETON 1 %

Volume After Curing: 969.9 cm^3

FLYASH %

Final Moisture Content: 27.1 %

CEMENT %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 559 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm^3)	VOLUME AFTER DRYING AND BRUSHING (cm^3)	WEIGHT AFTER DRYING AND BRUSHING (g)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during first immersion.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client:	TRANSPORT CANADA	Contract No.:	1 SD 83 · 00026
Project No.:	314 · 1264.02	Design Maximum Dry Density:	1665 kg/m^3
Sample:	Calgary: Airport	Design Optimum Moisture Content %:	18.5 %
	Sand 27 %, Silt 48 %, Clay 25 %	Initial Dry Density:	1754 kg/m^3
		Initial Moisture Content:	13.7 %
		Initial Volume:	938.6 cm^3
Stabilizer Dosage: FUJIBETON	1 %	Volume After Curing:	980.3 cm^3
FLYASH	%	Final Moisture Content:	23.3 %
CEMENT	%	Stabilized Soil Loss:	100 %

Method of Sample Preparation: ASTM D 559 · 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm^3)	VOLUME AFTER DRYING AND BRUSHING (cm^3)	WEIGHT AFTER DRYING AND BRUSHING (g)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during first inundation.

EBA Engineering Consultants Ltd.

eba

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1690 kg/m^3

Sample: Calgary: Airport

Sand 27 %, Silt 48 %, Clay 25 %

Design Optimum Moisture Content:% 16.2 %

Initial Dry Density: 1608 kg/m^3

Initial Moisture Content: 15.5 %

Initial Volume: 932.9 cm^3

Stabilizer Dosage: FUJIBETON 2 %

FLYASH %

CEMENT %

Volume After Curing: 976.2 cm^3

Final Moisture Content: 21.9 %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 559 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm^3)	VOLUME AFTER DRYING AND BRUSHING (cm^3)	WEIGHT AFTER DRYING AND BRUSHING (g)
1	934.6	902.8	
2	908.7	865.9	
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during third immersion.

EBA Engineering Consultants Ltd.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Project No.: 314 - 1264.02

Sample: Calgary: Airport

Sand 27 %, Silt 48 %, Clay 25 %

Stabilizer Dosage: FUJIBETON 2 %

FLYASH %

CEMENT %

Contract No.: 1 SD 83 - 00026

Design Maximum Dry Density: 1695 kg/m^3

Design Optimum Moisture Content: % 17.2 %

Initial Dry Density: 1711 kg/m^3

Initial Moisture Content: 15.3 %

Initial Volume: 940.1 cm^3

Volume After Curing: 951.8 cm^3

Final Moisture Content: 18.6 %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 559 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm^3)	VOLUME AFTER DRYING AND BRUSHING (cm^3)	WEIGHT AFTER DRYING AND BRUSHING (g)
1	959.5	916.7	1582.3
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during second inundation.

EBA Engineering Consultants Ltd.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Project No.: 314 - 1264.02

Sample: Calgary: Airport

Sand 27 %, Silt 48 %, Clay 25 %

Stabilizer Dosage: FUJIBETON 4 %

FLYASH %

CEMENT %

Contract No.: 1 SD 83 - 00026

Design Maximum Dry Density: 1712 kg/m^3

Design Optimum Moisture Content:% 16.7 %

Initial Dry Density: 1612 kg/m^3

Initial Moisture Content: 16.4 %

Initial Volume: 935.8 cm^3

Volume After Curing: 927.8 cm^3

Final Moisture Content: --- %

Stabilized Soil Loss: 34 %

Method of Sample Preparation: ASTM D 559 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm^3)	VOLUME AFTER DRYING AND BRUSHING (cm^3)	WEIGHT AFTER DRYING AND BRUSHING (g)
1	931.5	893.7	1525.9
2	914.5	908.5	1497.1
3	929.4	915.9	1430.4
4	911.7	917.4	1392.1
5	910.1	932.6	1363.2
6	878.7	900.0	1331.4
7	891.5	881.8	1300.2
8	875.6	884.9	1266.6
9	854.0	851.9	1211.3
10	811.9	817.5	1155.8
11	801.5	761.6	1083.7
12	725.6	---	1014.9

Remarks: Unconfined Compressive Strength after durability test not determined due to sample shape.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1790 kg/m³

Sample: Calgary: Airport

Design Optimum Moisture Content:% 16.8 %

Sand 27 %, Silt 48 %, Clay 25 %

Initial Dry Density: 1744 kg/m³

Initial Moisture Content: 13.7 %

Initial Volume: 945.0 cm³

Stabilizer Dosage: FUJIBETON 4 %

Volume After Curing: 1124.1 cm³

FLYASH %

Final Moisture Content: --- %

CEMENT %

Stabilized Soil Loss: 19 %

Method of Sample Preparation: ASTM D 559 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm³)	VOLUME AFTER DRYING AND BRUSHING (cm³)	WEIGHT AFTER DRYING AND BRUSHING (g)
1	955.1	914.5	1612.5
2	920.6	919.4	1603.0
3	913.4	914.1	1556.1
4	909.7	912.7	1523.8
5	907.8	898.4	1516.6
6	899.9	917.0	1495.6
7	891.1	905.1	1482.6
8	897.5	854.2	1464.3
9	840.0	856.4	1438.3
10	850.0	898.2	1426.1
11	896.1	860.6	1391.5
12	847.7	888.1	1358.9

Remarks: Unconfined Compressive Strength after durability test determined as 1.5 MPa.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1700 kg/m³

Sample: Calgary: Airport

Sand 27 %, Silt 48 %, Clay 25 %

Design Optimum Moisture Content:% 18.2 %

Initial Dry Density: 1624 kg/m³

Initial Moisture Content: 11.6 %

Initial Volume: 933.9 cm³

Stabilizer Dosage: FUJIBETON 6 %

Volume After Curing: 946.2 cm³

FLYASH %

Final Moisture Content: --- %

CEMENT %

Stabilized Soil Loss: 17 %

Method of Sample Preparation: ASTM D 559 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm³)	VOLUME AFTER DRYING AND BRUSHING (cm³)	WEIGHT AFTER DRYING AND BRUSHING (g)
1	922.2	914.1	1518.6
2	905.4	920.4	1530.1
3	786.9	902.3	1475.6
4	907.2	893.4	1456.5
5	895.1	907.8	1454.7
6	908.8	913.2	1435.6
7	904.7	910.5	1414.5
8	896.5	913.9	1410.7
9	888.5	900.8	1390.9
10	893.3	895.9	1383.8
11	903.1	891.3	1363.6
12	913.2	877.0	1347.5

Remarks: Unconfined Compressive Strength after durability test determined as 0.98 MPa.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1665 kg/m³

Sample: Calgary: Airport

Design Optimum Moisture Content:% 18.5 %

Sand 27 %, Silt 48 %, Clay 25 %

Initial Dry Density: 1712 kg/m³

Initial Moisture Content: 16.5 %

Initial Volume: 941.2 cm³

Stabilizer Dosage: FUJIBETON 6 %

Volume After Curing: 962.4 cm³

FLYASH ___ %

Final Moisture Content: --- %

CEMENT ___ %

Stabilized Soil Loss: 7.5 %

Method of Sample Preparation: ASTM D 559 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm³)	VOLUME AFTER DRYING AND BRUSHING (cm³)	WEIGHT AFTER DRYING AND BRUSHING (g)
1	1000.2	893.0	1590.5
2	936.2	915.3	1622.5
3	853.3	909.2	1571.2
4	927.2	898.6	1516.7
5	906.9	903.2	1575.5
6	936.1	919.1	1559.0
7	926.0	923.7	1546.1
8	940.4	921.4	1563.0
9	893.6	925.7	1538.4
10	916.6	923.4	1540.4
11	905.3	924.1	1527.4
12	932.1	904.9	1516.0

Remarks: Unconfined Compressive Strength after durability test determined as 3.5 MPa.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1731 kg/m³

Sample: Calgary: Airport

Design Optimum Moisture Content:% 16.8 %

Sand 27 %, Silt 48 %, Clay 25 %

Initial Dry Density: 1635 kg/m³

Initial Moisture Content: 16.8 %

Initial Volume: 932.1 cm³

Stabilizer Dosage: FUJIBETON 10 %

Volume After Curing: 942.9 cm³

FLYASH %

Final Moisture Content: --- %

CEMENT %

Stabilized Soil Loss: 4.3 %

Method of Sample Preparation: ASTM D 559 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm³)	VOLUME AFTER DRYING AND BRUSHING (cm³)	WEIGHT AFTER DRYING AND BRUSHING (g)
1	1016.0	899.5	1548.9
2	919.0	918.7	1588.5
3	851.1	894.4	1535.2
4	904.1	896.9	1534.9
5	890.1	907.0	1554.9
6	890.3	914.6	1544.5
7	907.0	802.5	1526.9
8	909.8	925.0	1539.5
9	914.9	909.0	1525.1
10	913.1	916.7	1522.3
11	914.9	909.8	1516.2
12	916.7	906.7	1511.1

Remarks: Unconfined Compressive Strength after durability test determined as 5.6 MPa.

EBA Engineering Consultants Ltd.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1690 kg/m3

Sample: Calgary: Airport

Sand 27 %, Silt 48 %, Clay 25 %

Design Optimum Moisture Content:% 18.0 %

Initial Dry Density: 1728 kg/m3

Initial Moisture Content: 16.1 %

Initial Volume: 938.7 cm3

Stabilizer Dosage: FUJIBETON 10 %

FLYASH %

CEMENT %

Volume After Curing: 962.6 cm3

Final Moisture Content: --- %

Stabilized Soil Loss: 8.9 %

Method of Sample Preparation: ASTM D 559 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm^3)	VOLUME AFTER DRYING AND BRUSHING (cm^3)	WEIGHT AFTER DRYING AND BRUSHING (g)
1	962.2	903.7	1568.0
2	923.2	920.3	1621.4
3	933.2	917.9	1552.9
4	903.6	899.1	1547.2
5	904.4	896.9	1577.8
6	933.5	915.9	1569.6
7	923.0	933.8	1546.1
8	924.7	918.3	1571.7
9	908.7	918.7	1537.4
10	920.3	923.8	1544.7
11	919.7	925.4	1530.0
12	917.9	919.1	1522.9

Remarks: Unconfined Compressive Strength after durability test determined as 5.3 MPa.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1765 kg/m3

Sample: Calgary: Airport

Sand 27 %, Silt 48 %, Clay 25 %

Design Optimum Moisture Content:% 12.8 %

Initial Dry Density: 1663 kg/m3

Initial Moisture Content: 13.0 %

Initial Volume: 930.6 cm3

Stabilizer Dosage: FUJIBETON ______ %

FLYASH 2 %

CEMENT ______ %

Volume After Curing: --- cm3

Final Moisture Content: 27.1 %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 559 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm3)	VOLUME AFTER DRYING AND BRUSHING (cm3)	WEIGHT AFTER DRYING AND BRUSHING (g)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during initial curing period.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client:	TRANSPORT CANADA	Contract No.:	1 SD 83 · 00026
Project No.:	314 · 1264.02	Design Maximum Dry Density:	1675 kg/m3
Sample:	Calgary: Airport	Design Optimum Moisture Content:%	18.5 %
	Sand 27 %, Silt 48 %, Clay 25 %	Initial Dry Density:	1660 kg/m3
		Initial Moisture Content:	18.0 %
		Initial Volume:	934.7 cm3
Stabilizer Dosage FUJIBETON	%	Volume After Curing:	--- cm3
FLYASH	2 %	Final Moisture Content:	28.6 %
CEMENT	%	Stabilized Soil Loss:	100 %

Method of Sample Preparation: ASTM D 559 · 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm3)	VOLUME AFTER DRYING AND BRUSHING (cm3)	WEIGHT AFTER DRYING AND BRUSHING (g)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during initial curing period.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client:	TRANSPORT CANADA	Contract No.:	1 SD 83 - 00026
Project No.:	314 - 1264.02	Design Maximum Dry Density:	1747 kg/m³
Sample:	Calgary: Airport	Design Optimum Moisture Content:%	14.0 %
	Sand 27 %, Silt 48 %, Clay 25 %	Initial Dry Density:	1613 kg/m³
		Initial Moisture Content:	11.6 %
		Initial Volume:	933.6 cm³
Stabilizer Dosage: FUJIBETON	%	Volume After Curing:	--- cm³
FLYASH	6 %	Final Moisture Content:	29.0 %
CEMENT	%	Stabilized Soil Loss:	100 %

Method of Sample Preparation: ASTM D 559 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm³)	VOLUME AFTER DRYING AND BRUSHING (cm³)	WEIGHT AFTER DRYING AND BRUSHING (g)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during initial curing period.

WET/DRY DURABILITY TEST

Project:	Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers		
Client:	TRANSPORT CANADA	Contract No.:	1 SD 83 · 00026
Project No.:	314 · 1264.02	Design Maximum Dry Density:	1663 kg/m³
Sample:	Calgary: Airport	Design Optimum Moisture Content: %	17.5 %
	Sand 27 %, Silt 48 %, Clay 25 %	Initial Dry Density:	1634 kg/m³
		Initial Moisture Content:	17.1 %
		Initial Volume:	936.5 cm³
Stabilizer Dosage: FUJIBETON	%	Volume After Curing:	--- cm³
FLYASH	6 %	Final Moisture Content:	26.1 %
CEMENT	%	Stabilized Soil Loss:	100 %

Method of Sample Preparation: ASTM D 559 · 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm³)	VOLUME AFTER DRYING AND BRUSHING (cm³)	WEIGHT AFTER DRYING AND BRUSHING (g)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during initial curing period.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1775 kg/m3

Sample: Calgary: Airport

Design Optimum Moisture Content:%: 12.7 %

Sand 27 %, Silt 48 %, Clay 25 %

Initial Dry Density: 1646 kg/m3

Initial Moisture Content: 13.6 %

Initial Volume: 951.1 cm3

Stabilizer Dosage: FUJIBETON ______ %

Volume After Curing: 100.4 cm3

FLYASH 10 %

Final Moisture Content: 24.4 %

CEMENT ______ %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 559 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm3)	VOLUME AFTER DRYING AND BRUSHING (cm3)	WEIGHT AFTER DRYING AND BRUSHING (g)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during first immersion.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1669 kg/m³

Sample: Calgary: Airport

Sand 27 %, Silt 48 %, Clay 25 %

Design Optimum Moisture Content: % 18.5 %

Initial Dry Density: 1655 kg/m³

Initial Moisture Content: 19.7 %

Initial Volume: 936.5 cm³

Stabilizer Dosage: FUJIBETON ______ %

FLYASH 10 %

CEMENT ______ %

Volume After Curing: --- cm³

Final Moisture Content: 27.0 %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 559 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm^3)	VOLUME AFTER DRYING AND BRUSHING (cm^3)	WEIGHT AFTER DRYING AND BRUSHING (g)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during initial curing period.

2

EBA Engineering Consultants Ltd.

eba

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1747 kg/m3

Sample: Calgary: Airport

Design Optimum Moisture Content:% 11.7 %

Sand 27 %, Silt 48 %, Clay 25 %

Initial Dry Density: 1648 kg/m3

Initial Moisture Content: 11.9 %

Initial Volume: 917.0 cm3

Stabilizer Dosage: FUJIBETON ____ %

Volume After Curing: --- cm3

FLYASH 13 %

Final Moisture Content: 24.4 %

CEMENT ____ %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 559 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm3)	VOLUME AFTER DRYING AND BRUSHING (cm3)	WEIGHT AFTER DRYING AND BRUSHING (g)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during initial curing period.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA	Contract No.: 1 SD 83 · 00026
Project No.: 314 · 1264.02	Design Maximum Dry Density: 1660 kg/m3
Sample: Calgary: Airport	Design Optimum Moisture Content:% 17.7 %
Sand 27 %, Silt 48 %, Clay 25 %	Initial Dry Density: 1660 kg/m3
	Initial Moisture Content: 17.0 %
	Initial Volume: 940.4 cm3
Stabilizer Dosage: FUJIBETON %	Volume After Curing: --- cm3
FLYASH 13 %	Final Moisture Content: 24.5 %
CEMENT %	Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 559 · 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm3)	VOLUME AFTER DRYING AND BRUSHING (cm3)	WEIGHT AFTER DRYING AND BRUSHING (g)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during initial curing period.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 · 00026

Project No.: 314 · 1264.02

Design Maximum Dry Density: 1726 kg/m3

Sample: Calgary: Airport

Design Optimum Moisture Content:% 15.6 %

Sand 27 %, Silt 48 %, Clay 25 %

Initial Dry Density: 1731.5 kg m3

Initial Moisture Content: 14.2 %

Initial Volume: 933.7 cm3

Stabilizer Dosage: FUJIBETON %

Volume After Curing: 926.0 cm3

FLYASH 5 %

Final Moisture Content: --- %

CEMENT 3 %

Stabilized Soil Loss: 25 %

Method of Sample Preparation: ASTM D 559 · 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm^3)	VOLUME AFTER DRYING AND BRUSHING (cm^3)	WEIGHT AFTER DRYING AND BRUSHING (g)
1	980.0	904.6	1603.9
2	923.8	928.6	1589.2
3	914.1	984.4	1527.7
4	917.3	929.9	1489.4
5	915.6	868.1	1468.0
6	885.4	893.7	1434.7
7	896.3	863.3	1406.1
8	858.1	908.8	1391.4
9	870.8	837.9	1352.7
10	813.9	892.9	1328.3
11	869.5	831.9	1281.6
12	785.8	844.5	1242.6

Remarks: Unconfined Compressive Strength after durability test determined as 1.3 MPa.

EBA Engineering Consultants Ltd.

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1745 kg/m^3

Sample: Calgary: Airport

Design Optimum Moisture Content: 16.0 %

Sand 27 %, Silt 48 %, Clay 25 %

Initial Dry Density: 1665 kg/m^3

Initial Moisture Content: 14.7 %

Initial Volume: 925.9 cm^3

Stabilizer Dosage: FUJIBETON ___ %

Volume After Curing: ___ cm^3

FLYASH 5 %

Final Moisture Content: 18.8 %

CEMENT 3 %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 560 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm^3)	WEIGHT AFTER THAWING AND BRUSHING (g)
1	924.4	1876.6
2	925.8	1730.7
3	757.9	1426.6
4	653.7	1203.2
5	581.4	958.3
6	408.5	790.2
7	352.3	659.9
8	293.2	520.2
9	249.4	440.7
10	181.3	326.5
11		
12		

Remarks: Sample disintegrated during eleventh thawing period.

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1747 kg/m3

Sample: Calgary: Airport

Sand 27 %, Silt 48 %, Clay 25 %

Design Optimum Moisture Content: 10.6 %

Initial Dry Density: 1638 kg/m3

Initial Moisture Content: 11.4 %

Initial Volume: 942.7 cm3

Stabilizer Dosage: FUJIBETON 1 %

FLYASH %

CEMENT %

Volume After Curing: --- cm3

Final Moisture Content: 22.7 %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 560 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm3)	WEIGHT AFTER THAWING AND BRUSHING (g)
1	972.0	1907.6
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated during second thawing period

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Project No.: 314 - 1264.02

Sample: Calgary: Airport

Sand 27 %, Silt 48 %, Clay 25 %

Stabilizer Dosage: FUJIBETON 1 %

FLYASH %

CEMENT %

Contract No.: 1 SD 83 - 00026

Design Maximum Dry Density: 1665 kg/m^3

Design Optimum Moisture Content: 18.5 %

Initial Dry Density: 1728 kg/m^3

Initial Moisture Content: 16.6 %

Initial Volume: 933.3 cm^3

Volume After Curing: --- cm^3

Final Moisture Content: 23.1 %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 560 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm^3)	WEIGHT AFTER THAWING AND BRUSHING (g)
1	972.4	1957.5
2	949.0	1801.6
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated during third thawing period

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA	Contract No.: 1 SD 83 - 00026
Project No.: 314 - 1264.02	Design Maximum Dry Density: 1690 kg/m^3
Sample: Calgary: Airport	Design Optimum Moisture Content: 16.2 %
Sand 27 %, Silt 48 %, Clay 25 %	Initial Dry Density: 1602 kg/m^3
	Initial Moisture Content: 15.8 %
	Initial Volume: 944.0 cm^3
Stabilizer Dosage: FUJIBETON 2 %	Volume After Curing: --- cm^3
FLYASH %	Final Moisture Content: 19.9 %
CEMENT %	Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 560 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm^3)	WEIGHT AFTER THAWING AND BRUSHING (g)
1	962.9	1830.1
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated during second thawing period

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1695 kg/m³

Sample: Calgary: Airport

Design Optimum Moisture Content: 17.2 %

Sand 27 %, Silt 48 %, Clay 25 %

Initial Dry Density: 1719 kg/m³

Initial Moisture Content: 14.9 %

Initial Volume: 937.2 cm³

Stabilizer Dosage: FUJIBETON 2 %

FLYASH %

CEMENT %

Volume After Curing: --- cm³

Final Moisture Content: 22.2 %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 560 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm³)	WEIGHT AFTER THAWING AND BRUSHING (g)
1	958.8	1928.2
2	859.5	1625.4
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated during third thawing period

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1712 kg/m^3

Sample: Calgary: Airport

Sand 27 %, Silt 48 %, Clay 25 %

Design Optimum Moisture Content: 16.7 %

Initial Dry Density: 1640 kg/m^3

Initial Moisture Content: 15.1 %

Initial Volume: 928.9 cm^3

Stabilizer Dosage: FUJIBETON 4 %

FLYASH %

CEMENT %

Volume After Curing: --- cm^3

Final Moisture Content: 18.9 %

Stabilized Soil Loss: 77 %

Method of Sample Preparation: ASTM D 560 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm^3)	WEIGHT AFTER THAWING AND BRUSHING (g)
1	954.8	1856.6
2	933.8	1783.4
3	918.7	1624.7
4	715.7	1403.5
5	680.3	1222.7
6	542.5	1049.2
7	533.5	930.1
8	409.1	786.6
9	403.8	705.9
10	364.5	589.2
11	286.9	490.4
12	223.8	414.4

Remarks: Unconfined compressive strength after durability test determined as 0.48 MPa

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1790 kg/m³

Sample: Calgary: Airport

Sand 27 %, Silt 48 %, Clay 25 %

Design Optimum Moisture Content: 16.8 %

Initial Dry Density: 1724 kg/m³

Initial Moisture Content: 14.7 %

Initial Volume: 942.8 cm³

Stabilizer Dosage: FUJIBETON 4 %

FLYASH %

CEMENT %

Volume After Curing: --- cm³

Final Moisture Content: 26.3 %

Stabilized Soil Loss: 59 %

Method of Sample Preparation: ASTM D 560 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm³)	WEIGHT AFTER THAWING AND BRUSHING (g)
1	973.5	1933.3
2	943.0	1852.1
3	884.6	1716.8
4	812.3	1594.4
5	744.8	1464.5
6	676.8	1323.8
7	649.8	1229.1
8	574.2	1110.1
9	507.3	1068.4
10	500.4	887.5
11	429.9	859.3
12	443.7	831.6

Remarks: Unconfined compressive strength after durability test determined as 0.70 MPa

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Project No.: 314 - 1264.02

Sample: Calgary: Airport
Sand 27 %, Silt 48 %, Clay 25 %

Stabilizer Dosage: FUJIBETON 6 %
FLYASH %
CEMENT %

Contract No.: 1 SD 83 - 00026

Design Maximum Dry Density: 1700 kg/m^3

Design Optimum Moisture Content: 18.2 %

Initial Dry Density: 1624 kg/m^3

Initial Moisture Content: 17.1 %

Initial Volume: 937.4 cm^3

Volume After Curing: --- cm^3

Final Moisture Content: 19.5 %

Stabilized Soil Loss: 74 %

Method of Sample Preparation: ASTM D 560 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm^3)	WEIGHT AFTER THAWING AND BRUSHING (g)
1	942.4	1834.5
2	935.2	1767.9
3	851.8	1603.2
4	757.1	1408.9
5	641.1	1209.4
6	576.4	1048.2
7	551.5	952.6
8	453.4	828.1
9	447.4	773.9
10	382.7	663.6
11	296.7	559.8
12	277.0	482.4

Remarks: Unconfined compressive strength after durability test determined as 0.67 MPa

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Project No.: 314 - 1264.02

Sample: Calgary: Airport

Sand 27 %, Silt 48 %, Clay 25 %

Stabilizer Dosage: FUJIBETON 6 %

FLYASH %

CEMENT %

Contract No.: 1 SD 83 - 00026

Design Maximum Dry Density: 1665 kg/m³

Design Optimum Moisture Content: 18.5 %

Initial Dry Density: 1714 kg/m³

Initial Moisture Content: 16.8 %

Initial Volume: 933.4 cm³

Volume After Curing: --- cm³

Final Moisture Content: 18.5 %

Stabilized Soil Loss: 33 %

Method of Sample Preparation: ASTM D 560 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm³)	WEIGHT AFTER THAWING AND BRUSHING (g)
1	951.3	1928.4
2	958.7	1904.7
3	950.5	1877.0
4	931.8	1852.2
5	921.9	1798.7
6	918.7	1712.0
7	804.2	1642.6
8	798.9	1545.1
9	784.1	1556.6
10	718.2	1436.6
11	699.0	1360.6
12	643.9	1279.1

Remarks: Unconfined compressive strength after durability test determined as 0.32 MPa

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1731 kg/m3

Sample: Calgary: Airport

Sand 27 %, Silt 48 %, Clay 25 %

Design Optimum Moisture Content: 16.8 %

Initial Dry Density: 1642 kg/m3

Initial Moisture Content: 16.4 %

Initial Volume: 940.8 cm3

Stabilizer Dosage: FUJIBETON 10 %

FLYASH %

CEMENT %

Volume After Curing: --- cm3

Final Moisture Content: 19.5 %

Stabilized Soil Loss: 38 %

Method of Sample Preparation: ASTM D 560 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm^3)	WEIGHT AFTER THAWING AND BRUSHING (g)
1	958.3	1841.7
2	921.4	1838.8
3	928.4	1833.5
4	942.6	1817.0
5	958.2	1781.0
6	895.9	1684.4
7	904.7	1610.5
8	809.5	1475.0
9	788.1	1413.1
10	737.8	1303.4
11	664.0	1215.4
12	652.7	1149.6

Remarks: Unconfined compressive strength after durability test determined as 1.7 MPa

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Project No.: 314 - 1264.02

Sample: Calgary: Airport
Sand 27 %, Silt 48 %, Clay 25 %

Stabilizer Dosage: FUJIBETON 10 %
FLYASH %
CEMENT %

Contract No.: 1 SD 83 - 00026

Design Maximum Dry Density: 1690 kg/m^3

Design Optimum Moisture Content: 18.0 %

Initial Dry Density: 1711 kg/m^3

Initial Moisture Content: 16.5 %

Initial Volume: 941.1 cm^3

Volume After Curing: --- cm^3

Final Moisture Content: 18.9 %

Stabilized Soil Loss: 48 %

Method of Sample Preparation: ASTM D 560 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm^3)	WEIGHT AFTER THAWING AND BRUSHING (g)
1	964.2	1924.2
2	961.4	1820.8
3	911.9	1742.8
4	935.7	1668.0
5	805.3	1578.5
6	792.0	1461.6
7	687.3	1386.4
8	730.3	1307.4
9	726.9	1261.6
10	606.1	1147.1
11	529.5	1067.7
12	540.8	996.2

Remarks: Unconfined compressive strength after durability test determined as 1.0 MPa

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1765 kg/m3

Sample: Calgary: Airport

Design Optimum Moisture Content: 12.8 %

Sand 27 %, Silt 48 %, Clay 25 %

Initial Dry Density: 1681 kg/m3

Initial Moisture Content: 12.1 %

Initial Volume: 938.0 cm3

Stabilizer Dosage: FUJIBETON ______ %

Volume After Curing: --- cm3

FLYASH 2 %

Final Moisture Content: 29.9 %

CEMENT ______ %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 560 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm3)	WEIGHT AFTER THAWING AND BRUSHING (g)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated during first thawing period

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1675 kg/m3

Sample: Calgary: Airport

Design Optimum Moisture Content: 18.5 %

Sand 27 %, Silt 48 %, Clay 25 %

Initial Dry Density: 1679 kg/m3

Initial Moisture Content: 17.6 %

Initial Volume: 937.8 cm3

Stabilizer Dosage: FUJIBETON %

Volume After Curing: --- cm3

FLYASH 2 %

Final Moisture Content: 27.5 %

CEMENT %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 560 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm3)	WEIGHT AFTER THAWING AND BRUSHING (g)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated during first thawing period

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1747 kg/m^3

Sample: Calgary: Airport

Sand 27 %, Silt 48 %, Clay 25 %

Design Optimum Moisture Content: 14.0 %

Initial Dry Density: 1634 kg/m^3

Initial Moisture Content: 10.0 %

Initial Volume: 931.6 cm^3

Stabilizer Dosage: FUJIBETON ___ %

FLYASH 6 %

CEMENT ___ %

Volume After Curing: --- cm^3

Final Moisture Content: 25.7 %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 560 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm^3)	WEIGHT AFTER THAWING AND BRUSHING (g)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated during first thawing period

EBA Engineering Consultants Ltd.

eba

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1663 kg/m^3

Sample: Calgary: Airport

Sand 27 %, Silt 48 %, Clay 25 %

Design Optimum Moisture Content: 17.5 %

Initial Dry Density: 1668 kg/m^3

Initial Moisture Content: 17.1 %

Initial Volume: 946.7 cm^3

Stabilizer Dosage: FUJIBETON ______ %

FLYASH 6 %

CEMENT ______ %

Volume After Curing: --- cm^3

Final Moisture Content: 26.5 %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 560 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm^3)	WEIGHT AFTER THAWING AND BRUSHING (g)
1	1013.7	1817.4
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated during second thawing period

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1SD83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1755 kg/m³

Sample: Calgary: Airport

Sand 27 %, Silt 48 %, Clay 25 %

Design Optimum Moisture Content: 12.7 %

Initial Dry Density: 1666 kg/m³

Initial Moisture Content: 12.2 %

Initial Volume: 931.9 cm³

Stabilizer Dosage: FUJIBETON %

FLYASH 10 %

CEMENT %

Volume After Curing: --- cm³

Final Moisture Content: 24.9 %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 560 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm³)	WEIGHT AFTER THAWING AND BRUSHING (g)
1	1013.1	1915.1
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated during second thawing period

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1669 kg/m³

Sample: Calgary: Airport

Design Optimum Moisture Content: 18.5 %

Sand 27 %, Silt 48 %, Clay 25 %

Initial Dry Density: 1676 kg/m³

Initial Moisture Content: 18.0 %

Initial Volume: 926.6 cm³

Stabilizer Dosage: FUJIBETON %

Volume After Curing: --- cm³

FLYASH 10 %

Final Moisture Content: 26.6 %

CEMENT %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 560 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm³)	WEIGHT AFTER THAWING AND BRUSHING (g)
1	1010.7	1926.4
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated during second thawing period

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1747 kg/m³

Sample: Calgary: Airport

Design Optimum Moisture Content: 11.7 %

Sand 27 %, Silt 48 %, Clay 25 %

Initial Dry Density: 1654 kg/m³

Initial Moisture Content: 11.7 %

Initial Volume: 935.0 cm³

Stabilizer Dosage: FUJIBETON %

Volume After Curing: --- cm³

FLYASH 13 %

Final Moisture Content: 24.7 %

CEMENT %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 560 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm³)	WEIGHT AFTER THAWING AND BRUSHING (g)
1	997.9	1921.1
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated during second thawing period

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1660 kg/m3

Sample: Calgary: Airport

Design Optimum Moisture Content: 17.7 %

Sand 27 %, Silt 48 %, Clay 25 %

Initial Dry Density: 1690 kg/m3

Initial Moisture Content: 17.3 %

Initial Volume: 932.2 cm3

Stabilizer Dosage: FUJIBETON _____ %

FLYASH 13 %

CEMENT _____ %

Volume After Curing: --- cm3

Final Moisture Content: 24.9 %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 560 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm3)	WEIGHT AFTER THAWING AND BRUSHING (g)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated during first thawing period

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1745 kg/m3

Sample: Calgary: Airport

Design Optimum Moisture Content: 16.0 %

Sand 27 %, Silt 48 %, Clay 25 %

Initial Dry Density: 1665 kg/m3

Initial Moisture Content: 14.7 %

Initial Volume: 925.9 cm3

Stabilizer Dosage: FUJIBETON %

Volume After Curing: --- cm3

FLYASH 5 %

Final Moisture Content: 18.8 %

CEMENT 3 %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 560 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm^3)	WEIGHT AFTER THAWING AND BRUSHING (g)
1	924.4	1876.6
2	925.8	1730.7
3	757.9	1426.6
4	653.7	1203.2
5	581.4	958.3
6	408.5	790.2
7	352.3	659.9
8	293.2	520.2
9	249.4	440.7
10	181.3	326.5
11		
12		

Remarks: Sample disintegrated during eleventh thawing period

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1726 kg/m^3

Sample: Calgary: Airport

Design Optimum Moisture Content: 15.6 %

Sand 27 %, Silt 48 %, Clay 25 %

Initial Dry Density: 1730 kg/m^3

Initial Moisture Content: 13.5 %

Initial Volume: 932.3 cm^3

Stabilizer Dosage: FUJIBETON %

Volume After Curing: --- cm^3

FLYASH 5 %

Final Moisture Content: 18.1 %

CEMENT 3 %

Stabilized Soil Loss: 80 %

Method of Sample Preparation: ASTM D 560 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm^3)	WEIGHT AFTER THAWING AND BRUSHING (g)
1	982.5	1929.6
2	930.8	1752.0
3	864.8	1551.4
4	733.6	1396.7
5	532.0	925.8
6	402.1	795.4
7	412.2	702.7
8	631.7	637.4
9	319.4	580.4
10	289.3	489.3
11	234.7	435.6
12	232.3	378.1

Remarks: Unconfined compressive strength after durability test determined as 0.26 MPa

APPENDIX D

LABORATORY TEST RESULTS
PINCHER CREEK

EBA Engineering Consultants Ltd.

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1SD83 - 00026

Project No.: 314 - 1264.02

Stabilizer Dosage: FUJIBETON 0 %

FLYASH 0 %

CEMENT 0 %

Sample: Pincher Creek

Sand 16%, Silt 46%, Clay 38%

TEST DATA:

1) Method of Sample Preparation: ASTM D 558 - 57

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m^3)
1	10.8	1560
2	15.7	1510
3	22.4	1482
4	28.0	1462
5	32.7	1395

Design Field Optimum Moisture Content: 28 %

Design Field Maximum Dry Density: 1470 kg/m^3

2) Method of Sample Preparation: ASTM D558 - 57, but using 19 blows to compact each layer instead of 25 blows

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m^3)
1	14.1	1393
2	19.3	1388
3	23.0	1454
4	29.4	1424
5	33.9	1346

Design Field Optimum Moisture Content: 25 %

Design Field Maximum Dry Density: 1460 kg/m^3

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

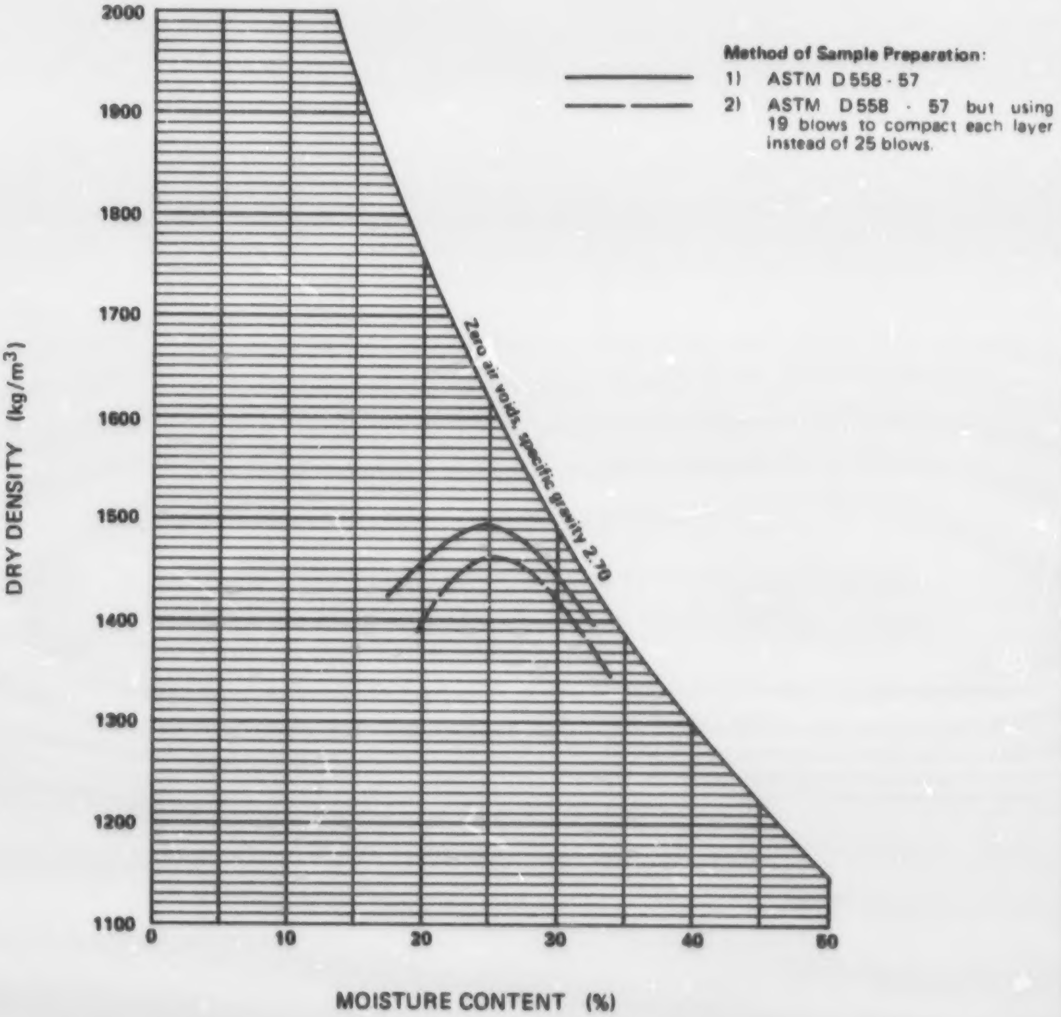
Stabilizer Dosage: FUJIBETON 0 %

Sample: Pincher Creek

FLYASH 0 %

Sand 16% , Silt 46% , Clay 38%

CEMENT 0 %



DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1SD83 - 00026

Project No.: 314 - 1264.02

Stabilizer Dosage: FUJIBETON 0 %

FLYASH 0 %

CEMENT 0 %

Sample: Pincher Creek

Sand 16 %, Silt 46 %, Clay 38 %

TEST DATA:

1) Method of Sample Preparation: ASTM D 558 - 57

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	14.0	1536
2	17.6	1493
3	22.2	1511
4	29.0	1460
5	35.0	1327

Design Field Optimum Moisture Content: 28 %

Design Field Maximum Dry Density: 1470 kg/m³

2) Method of Sample Preparation: ASTM D558 - 57, but using 19 blows to compact each layer instead of 25 blows

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	13.8	1436
2	18.1	1450
3	24.3	1446
4	28.9	1397
5	33.4	1350

Design Field Optimum Moisture Content: 25 %

Design Field Maximum Dry Density: 1460 kg/m³

EBA Engineering Consultants Ltd.

eba

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

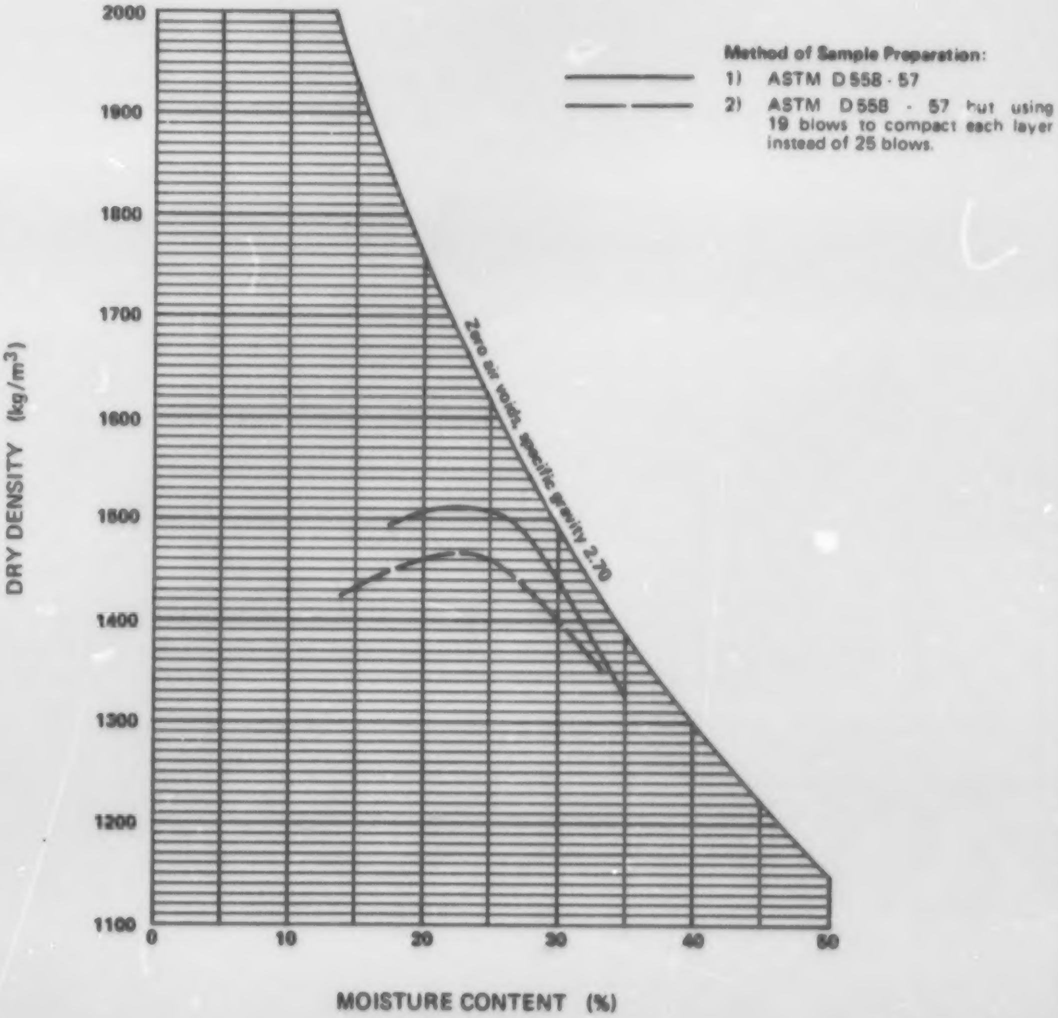
Stabilizer Dosage: FUJIBETON 0 %

Sample: Pincher Creek

FLYASH 0 %

Sand 16% , Silt 46% , Clay 38%

CEMENT 0 %



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Stabilizer Dosage: None

Sample: Pincher Creek

Sand 16% , Silt 46% , Clay 38%

Samples compacted using 100% of standard energy

TEST	DRY DENSITY (kg/m³)	MOISTURE CONTENT (%)	CALIFORNIA BEARING RATIO (%)	
			2.5 mm Penetration	5.0 mm Penetration
1	1536	14.0	31	27
2	1493	17.6	11	9.4
3	1511	22.2	9.7	8.0
4	1460	28.9	2.8	2.8
5	1327	35.0	1.2	1.0
6	1560	10.8	23	25
7	1510	15.7	14	14
8	1482	22.4	6.0	6.0
9	1462	28.0	3.8	2.7
10	1395	32.7	1.7	1.7

CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02 Stabilizer Dosage: None

Sample: Pincher Creek

Sand 16% , Silt 46% , Clay 38%

Samples compacted using 75 % of standard energy

TEST	DRY DENSITY (kg/m^3)	MOISTURE CONTENT (%)	CALIFORNIA BEARING RATIO (%)	
			2.5 mm Penetration	5.0 mm Penetration
1	1388	23.0	7.0	6.0
2	1424	29.4	3.5	3.1
3	1397	28.9	3.8	3.1
4	1446	24.3	6.5	5.6
5	1388	19.3	7.5	7.4
6	1450	18.1	7.3	10
7	1393	14.1	9.7	11
8	1436	13.8	13	13
9	1346	33.9	1.7	1.3
10	1350	33.4	1.7	1.3

ATTERBERG LIMITS TEST DATA

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264. 02

SAMPLE	STABILIZER DOSAGE (%)			REACTION TIME (hours)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX
	FUJIBETON	FLYASH	CEMENT				
Pincher Creek	0	0	0	–	28.1	54.2	26.1
	0	0	0	–	28.2	54.8	26.6
	2	–	–	0.25 (mix.)	28.5	62.5	34.0
	2	–	–	1	31.5	52.0	26.5
	2	–	–	24	34.8	61.9	27.1
	4	–	–	0.25 (mix.)	40.1	63.0	22.9
	4	–	–	1	34.4	52.8	18.4
	4	–	–	24	42.1	62.9	20.8
	7	–	–	0.25 (mix.)	–	–	Non Plastic
	7	–	–	1	–	–	Non Plastic
	7	–	–	24	–	–	Non Plastic
	9	–	–	0.25 (mix.)	–	–	Non Plastic
	9	–	–	1	–	–	Non Plastic
	9	–	–	24	–	–	Non Plastic
	12	–	–	0.25 (mix.)	–	–	Non Plastic
	12	–	–	1	–	–	Non Plastic
	12	–	–	24	–	–	Non Plastic
	16	–	–	0.25 (mix.)	–	–	Non Plastic
	16	–	–	1	–	–	Non Plastic
	16	–	–	24	–	–	Non Plastic
	–	2	–	0.25 (mix.)	26.1	53.0	27.1
	–	2	–	1	23.8	45.6	21.8
	–	2	–	24	24.1	43.5	19.4
	–	6	–	0.25 (mix.)	22.3	48.3	26.0
	–	6	–	1	25.6	46.2	20.6
	–	6	–	24	26.9	47.9	21.0
	–	10	–	0.25 (mix.)	23.8	47.6	23.8

EBA Engineering Consultants Ltd.

ATTERBERG LIMITS TEST DATA

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264. 02

SAMPLE	STABILIZER DOSAGE (%)			REACTION TIME (hours)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX
	FUJIBETON	FLYASH	CEMENT				
Pincher Creek	–	10	–	1	25.8	47.4	21.6
	–	10	–	24	27.4	50.4	23.0
	–	13	–	0.25 (mix.)	22.1	48.0	26.9
	–	13	–	1	16.9	23.1	6.2
	–	13	–	24	24.8	46.1	21.3
	–	16	–	0.25 (mix.)	27.6	47.2	19.6
	–	16	–	1	26.7	47.6	20.9
	–	16	–	24	29.8	48.4	18.6
	–	7	3	0.25 (mix.)	34.0	60.3	26.3
	–	7	3	1	52.8	75.0	22.8
	–	7	3	24	49.7	69.0	19.3

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA Contract No.: 1SD83 - 00026

Project No.: 314 - 1264.02 Stabilizer Dosage: FUJIBETON 2 %

Sample: Pincher Creek FLYASH %

Sand 16%, Silt 46%, Clay 38% CEMENT %

TEST DATA:

1) Method of Sample Preparation: ASTM D 558 - 57

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	20.5	1412
2	23.8	1439
3	29.9	1401
4	34.2	1339
5	39.7	1256

Design Field Optimum Moisture Content: 25.2 %

Design Field Maximum Dry Density: 1455 kg/m³

2) Method of Sample Preparation: ASTM D558 - 57, but using 19 blows to compact each layer instead of 25 blows

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	22.9	1418
2	33.5	1356
3	30.2	1381
4	30.3	1377
5		

Design Field Optimum Moisture Content: 24 %

Design Field Maximum Dry Density: 1490 kg/m³

SHEET 1 OF 2

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

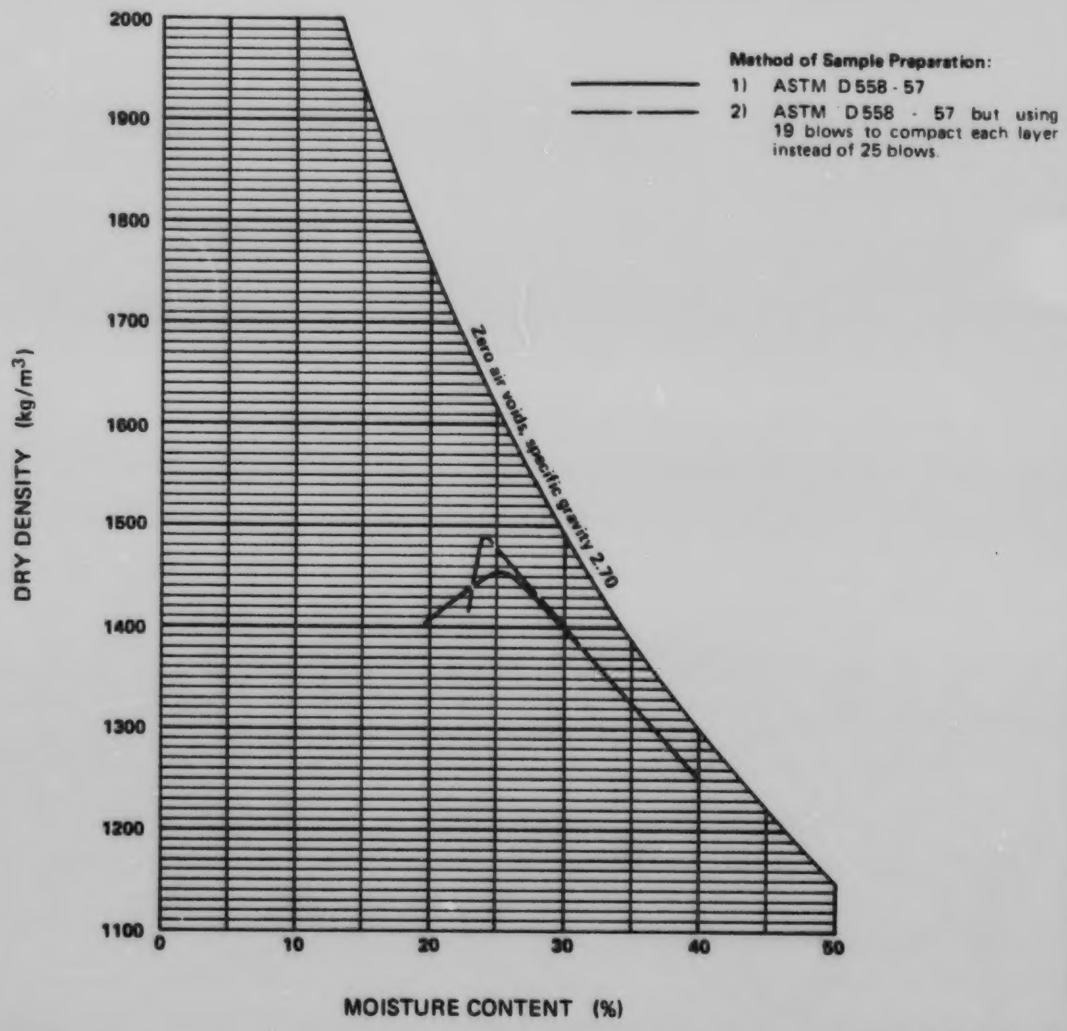
Stabilizer Dosage: FUJIBETON 2 %

FLYASH %

CEMENT %

Sample: Pincher Creek

Sand 16 %, Silt 46 %, Clay 38 %



DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA Contract No.: 1SD83 - 00026

Project No.: 314 - 1264.02 Stabilizer Dosage: FUJIBETON 4 %

Sample: Pincher Creek FLYASH %

Sand 16%, Silt 46%, Clay 38% CEMENT %

TEST DATA:

1) Method of Sample Preparation: ASTM D 558 - 57

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	20.2	1441
2	23.8	1449
3	30.0	1402
4	34.2	1368
5	39.0	1278

Design Field Optimum Moisture Content: 26 %

Design Field Maximum Dry Density: 1480 kg/m³

2) Method of Sample Preparation: ASTM D558 - 57, but using 19 blows to compact each layer instead of 25 blows

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	19.1	1484
2	25.5	1434
3	31.4	1364
4	33.7	1370
5		

Design Field Optimum Moisture Content: 2 6 %

Design Field Maximum Dry Density: 1435 kg/m³

SHEET 1 OF 2

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

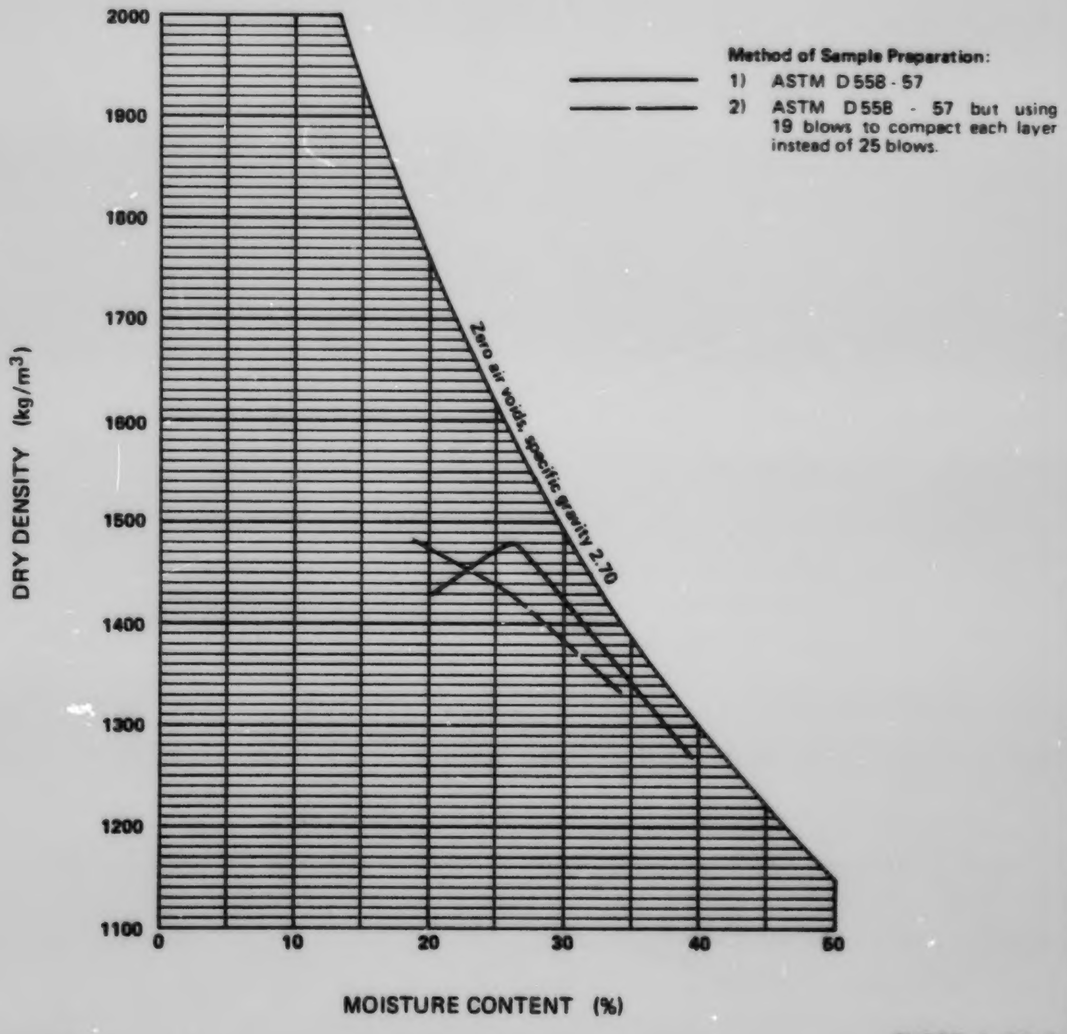
Stabilizer Dosage: FUJIBETON 4 %

FLYASH %

CEMENT %

Sample: Pincher Creek

Sand 16 %, Silt 46 %, Clay 38 %



SHEET 2 OF 2

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1SD83 - 00026

Project No.: 314 - 1264.02

Stabilizer Dosage: FUJIBETON 7 %

FLYASH %

CEMENT %

Sample: Pincher Creek

Sand 16%, Silt 46%, Clay 38%

TEST DATA:

1) Method of Sample Preparation: ASTM D 558 - 57

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	19.7	1499
2	24.4	1457
3	32.0	1385
4	34.5	1335
5	38.3	1263

Design Field Optimum Moisture Content: 15.2 %

Design Field Maximum Dry Density: 1542 kg/m³

2) Method of Sample Preparation: ASTM D558 - 57, but using 19 blows to compact each layer instead of 25 blows

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	5.0	1594
2	24.0	1482
3	18.6	1437
4	19.1	1412
5		

Design Field Optimum Moisture Content: 24 %

Design Field Maximum Dry Density: 1485 kg/m³

SHEET 1 OF 2

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

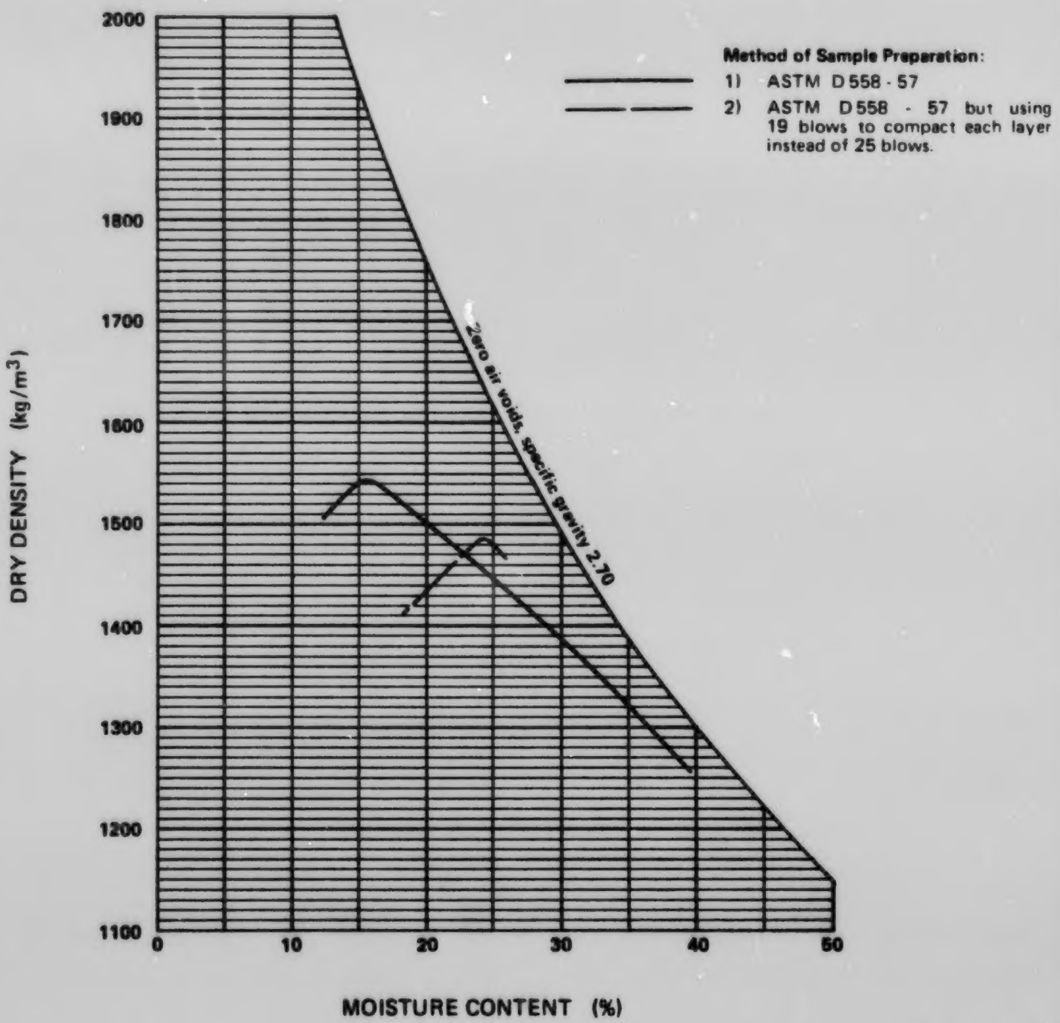
Stabilizer Dosage: FUJIBETON 7 %

FLYASH %

CEMENT %

Sample: Pincher Creek

Sand 16 %, Silt 46 %, Clay 38 %



SHEET 2 OF 2

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA   Contract No.: 1SD83 - 00026

Project No.: 314 - 1264.02   Stabilizer Dosage: FUJIBETON 9 %

Sample: Pincher Creek   FLYASH ____ %

Sand 16%, Silt 46%, Clay 38%   CEMENT ____ %

TEST DATA:

1) Method of Sample Preparation: ASTM D 558 - 57

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	20.0	1494
2	25.1	1514
3	30.4	1415
4	31.8	1373
5	40.2	1250

Design Field Optimum Moisture Content: 23 %

Design Field Maximum Dry Density: 1535 kg/m³

2) Method of Sample Preparation: ASTM D558 - 57, but using 19 blows to compact each layer instead of 25 blows

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	15.6	1509
2	28.9	1404
3	26.1	1404
4	26.7	1419
5		

Design Field Optimum Moisture Content: 25 %

Design Field Maximum Dry Density: 1450 kg/m³

SHEET 1 OF 2

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

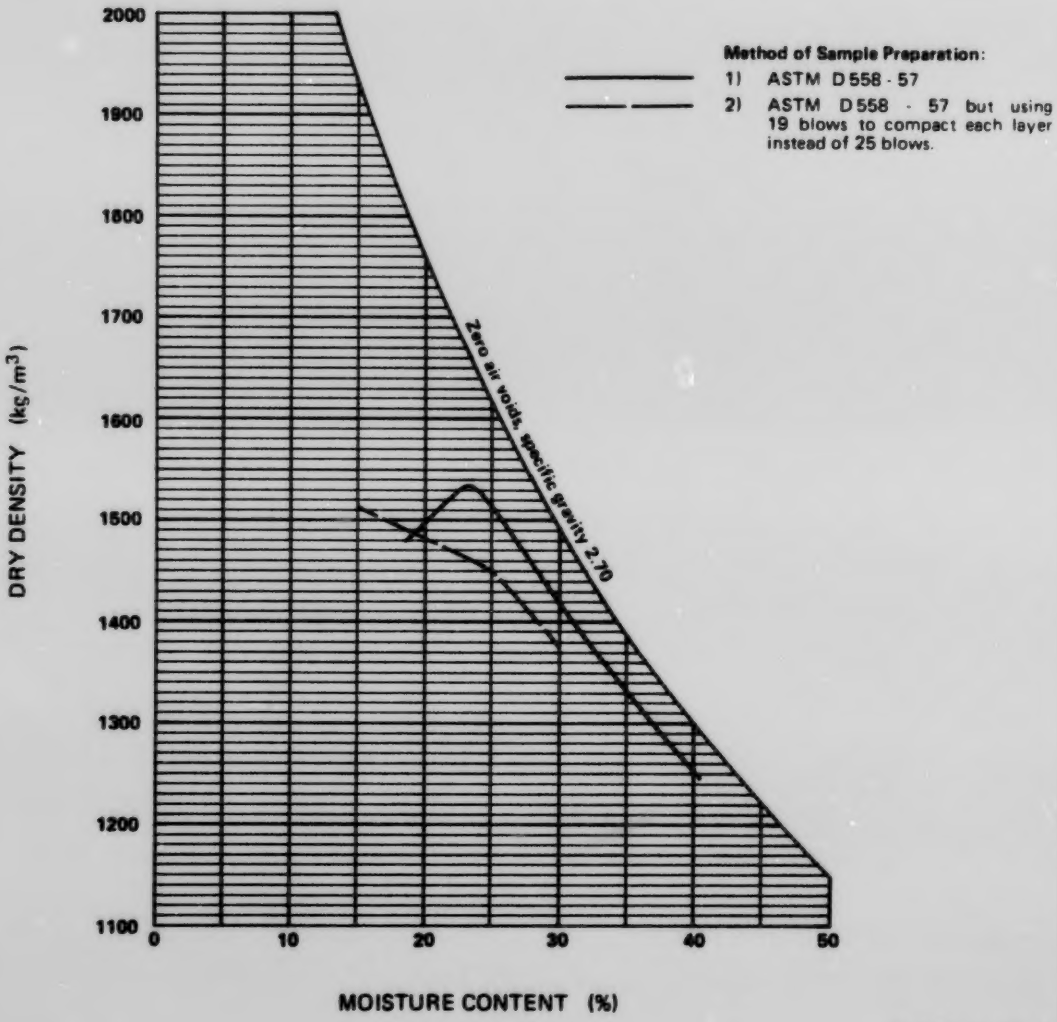
Stabilizer Dosage: FUJIBETON 9 %

FLYASH %

CEMENT %

Sample: Pincher Creek

Sand 16 %, Silt 46 %, Clay 38 %



SHEET 2 OF 2

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1SD83 - 00026

Project No.: 314 - 1264.02

Stabilizer Dosage: FUJIBETON 12 %

Sample: Pincher Creek

FLYASH %

Sand 16%, Silt 46%, Clay 38%

CEMENT %

TEST DATA:

1) Method of Sample Preparation: ASTM D 558 - 57

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	20.4	1514
2	25.0	1493
3	29.2	1450
4	35.3	1334
5	40.3	1242

Design Field Optimum Moisture Content: 17.1 %

Design Field Maximum Dry Density: 1541 kg/m³

2) Method of Sample Preparation: ASTM D558 - 57, but using 19 blows to compact each layer instead of 25 blows

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	9.2	1576
2	23.2	1480
3	19.3	1460
4	21.5	1454
5		

Design Field Optimum Moisture Content: 24.5 %

Design Field Maximum Dry Density: 1485 kg/m³

SHEET 1 OF 2

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

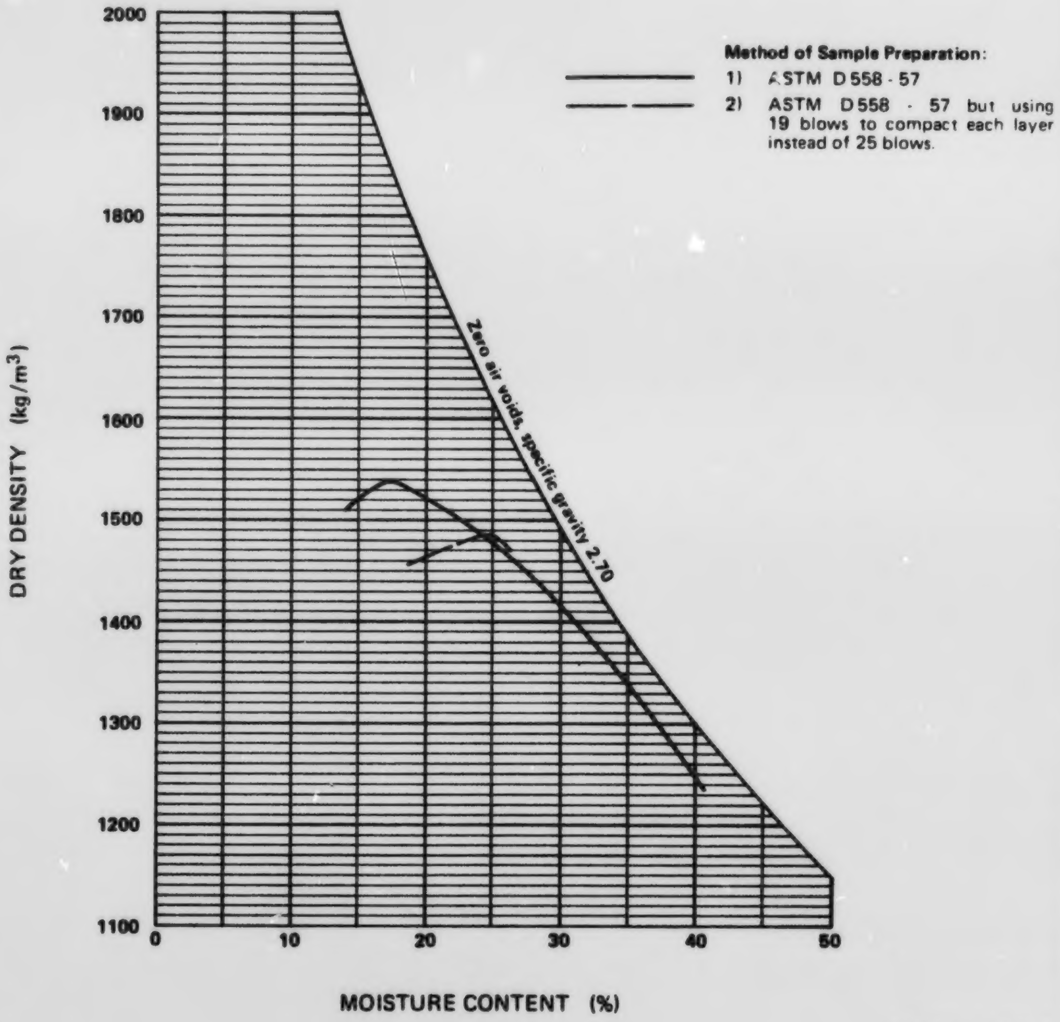
Stabilizer Dosage: FUJIBETON 12 %

Sample: Pincher Creek

FLYASH %

Sand 16 %, Silt 46 %, Clay 38 %

CEMENT %



SHEET 2 OF 2

EBA Engineering Consultants Ltd.

eba

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1SD83 - 00026

Project No.: 314 - 1264.02

Stabilizer Dosage: FUJIBETON ______ %

Sample: Pincher Creek

FLYASH 16 %

Sand 16%, Silt 46%, Clay 38%

CEMENT ______ %

TEST DATA:

1) Method of Sample Preparation: ASTM D 558 - 57

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	15.8	1530
2	18.9	1525
3	25.8	1470
4	31.4	1357
5	36.3	1253

Design Field Optimum Moisture Content: 16 %

Design Field Maximum Dry Density: 1735 kg/m³

2) Method of Sample Preparation: ASTM D558 - 57, but using 19 blows to compact each layer instead of 25 blows

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	0.0	1593
2	10.2	1519
3	21.8	1455
4	23.9	1421
5		

Design Field Optimum Moisture Content: 19 %

Design Field Maximum Dry Density: 1480 kg/m³

SHEET 1 OF 2

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

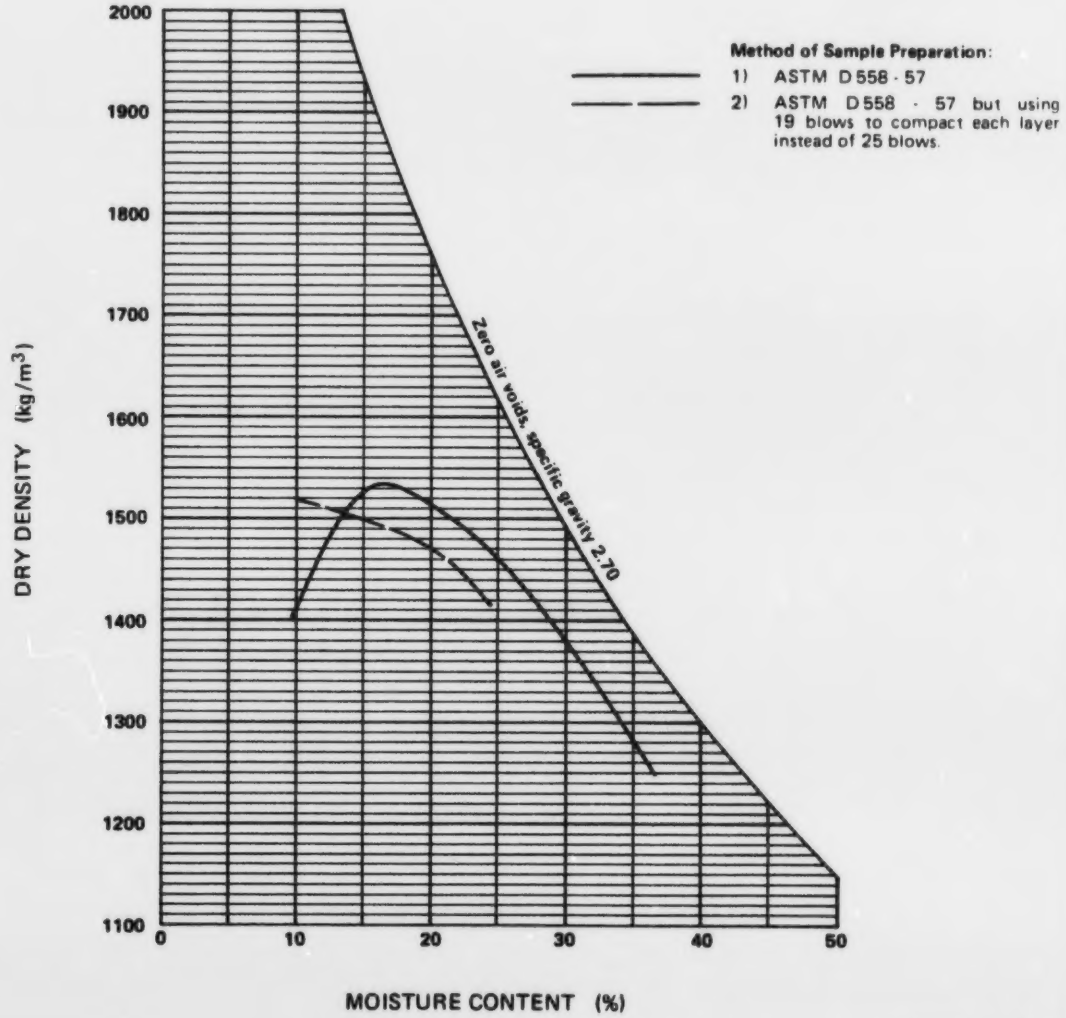
Stabilizer Dosage: FUJIBETON ______ %

Sample: Pincher Creek

FLYASH 16 %

Sand 16 %, Silt 46 %, Clay 38 %

CEMENT ______ %



DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1SD83 - 00026

Project No.: 314 - 1264.02

Stabilizer Dosage: FUJIBETON ______ %

Sample: Pincher Creek

FLYASH 2 %

Sand 16%, Silt 46%, Clay 38%

CEMENT ______ %

TEST DATA:

1) Method of Sample Preparation: ASTM D 558 - 57

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	20.6	1457
2	23.9	1543
3	30.2	1426
4	34.6	1338
5	14.6	1522

Design Field Optimum Moisture Content: 24.2 %

Design Field Maximum Dry Density: 1545 kg/m³

2) Method of Sample Preparation: ASTM D558 - 57, but using 19 blows to compact each layer instead of 25 blows

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	16.0	1424
2	29.8	1418
3	31.1	1408
4	35.7	1327
5		

Design Field Optimum Moisture Content: 25 %

Design Field Maximum Dry Density: 1480 kg/m³

SHEET 1 OF 2

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

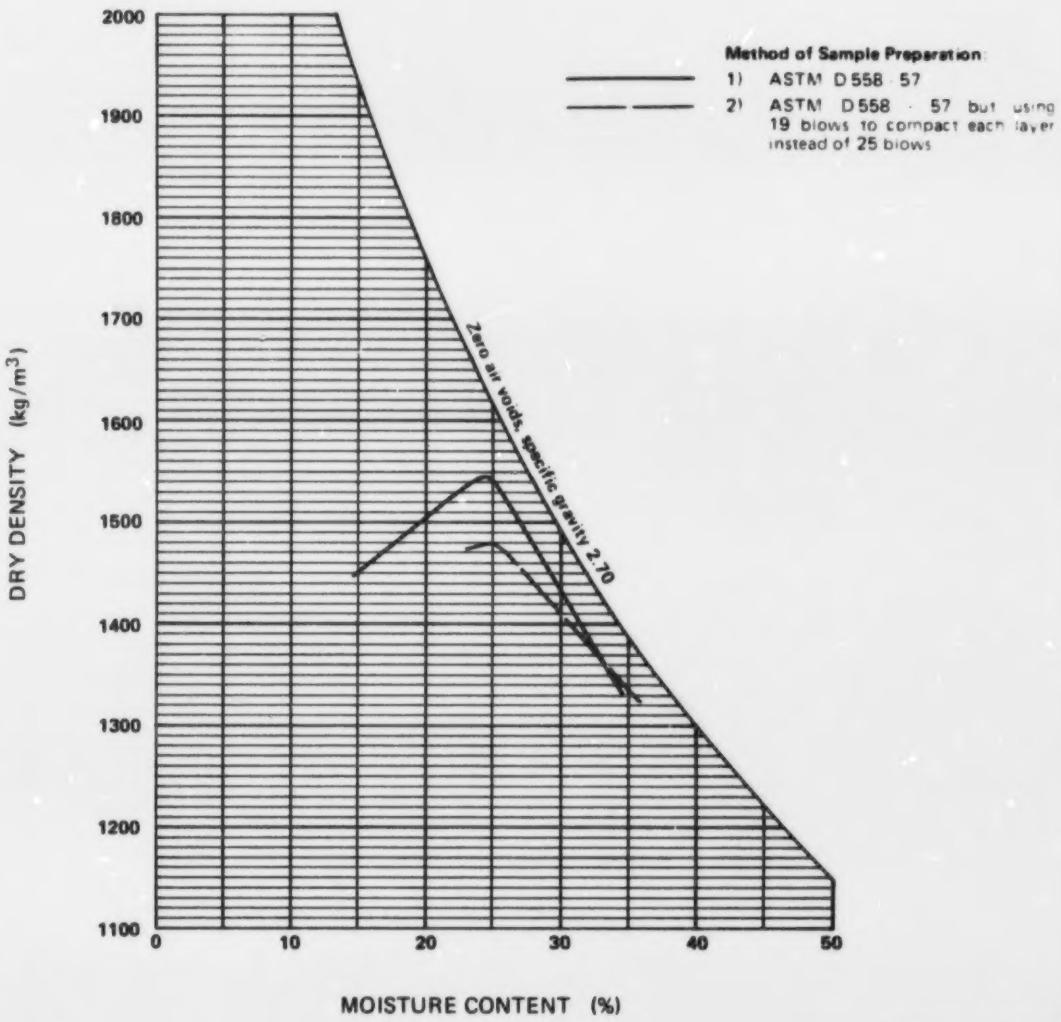
Stabilizer Dosage: FUJIBETON ______ %

Sample: Pincher Creek

FLYASH 2 %

Sand 16 %, Silt 46 %, Clay 38 %

CEMENT ______ %



SHEET 2 OF 2

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1SD83 - 00026

Project No.: 314 - 1264.02

Stabilizer Dosage: FUJIBETON ____ %

FLYASH 6 %

CEMENT ____ %

Sample: Pincher Creek

Sand 16%, Silt 46%, Clay 38%

TEST DATA:

1) Method of Sample Preparation: ASTM D 558 - 57

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	20.6	1516
2	24.3	1517
3	30.8	1404
4	35.6	1310
5	15.7	1486

Design Field Optimum Moisture Content: 22.5 %

Design Field Maximum Dry Density: 1540 kg/m³

2) Method of Sample Preparation: ASTM D558 - 57, but using 19 blows to compact each layer instead of 25 blows

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	15.3	1463
2	28.6	1421
3	29.3	1425
4	34.2	1329
5		

Design Field Optimum Moisture Content: 24 %

Design Field Maximum Dry Density: 1500 kg/m³

SHEET 1 OF 2

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

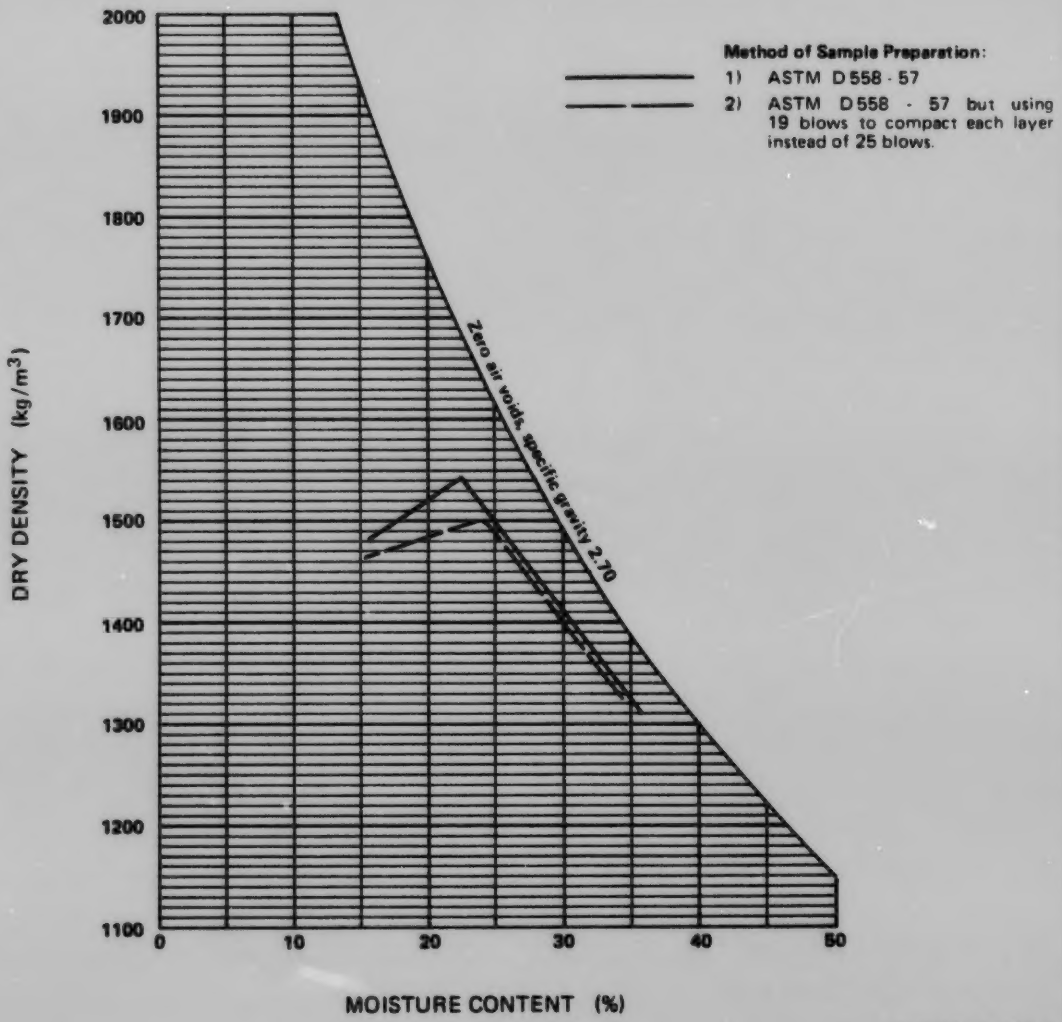
Stabilizer Dosage: FUJIBETON ______ %

Sample: Pincher Creek

FLYASH 6 %

Sand 16 %, Silt 46 %, Clay 38 %

CEMENT ______ %



DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1SD83 - 00026

Project No.: 314 - 1264.02

Stabilizer Dosage: FUJIBETON ______ %

FLYASH 10 %

CEMENT ______ %

Sample: Pincher Creek

Sand 16%, Silt 46%, Clay 38%

TEST DATA:

1) Method of Sample Preparation: ASTM D 558 - 57

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	20.6	1517
2	23.7	1523
3	29.3	1425
4	34.4	1335
5	17.0	1536

Design Field Optimum Moisture Content: 22.5 %

Design Field Maximum Dry Density: 1537 kg/m³

2) Method of Sample Preparation: ASTM D558 - 57, but using 19 blows to compact each layer instead of 25 blows

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	10.6	1489
2	28.2	1412
3	29.1	1409.7
4	24.4	1438
5		

Design Field Optimum Moisture Content: 23 %

Design Field Maximum Dry Density: 1460 kg/m³

SHEET 1 OF 2

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

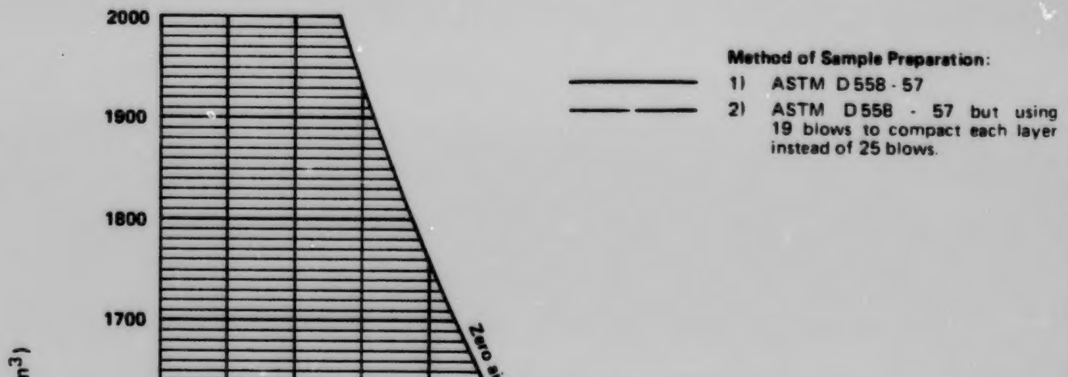
Stabilizer Dosage: FUJIBETON ______ %

Sample: Pincher Creek

FLYASH 10 %

Sand 16 %, Silt 46 %, Clay 38 %

CEMENT ______ %



EBA Engineering Consultants Ltd.

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA Contract No.: 1SD83 - 00026

Project No.: 314 - 1264.02 Stabilizer Dosage: FUJIBETON ____ %

Sample: Pincher Creek FLYASH 13 %

Sand 16%, Silt 46%, Clay 38% CEMENT ____ %

TEST DATA:

1) Method of Sample Preparation: ASTM D 558 - 57

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m^3)
1	21.1	1568
2	24.3	1522
3	29.7	1407
4	34.0	1319
5	15.0	1546

Design Field Optimum Moisture Content: 18.6 %

Design Field Maximum Dry Density: 1600 kg/m^3

2) Method of Sample Preparation: ASTM D558 - 57, but using 19 blows to compact each layer instead of 25 blows

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m^3)
1	10.0	1526
2	18.0	1430
3	24.3	1436
4	25.5	1450
5		

Design Field Optimum Moisture Content: 18 %

Design Field Maximum Dry Density: 1500 kg/m^3

DRY DENSITY/MOISTURE CONTENT
RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

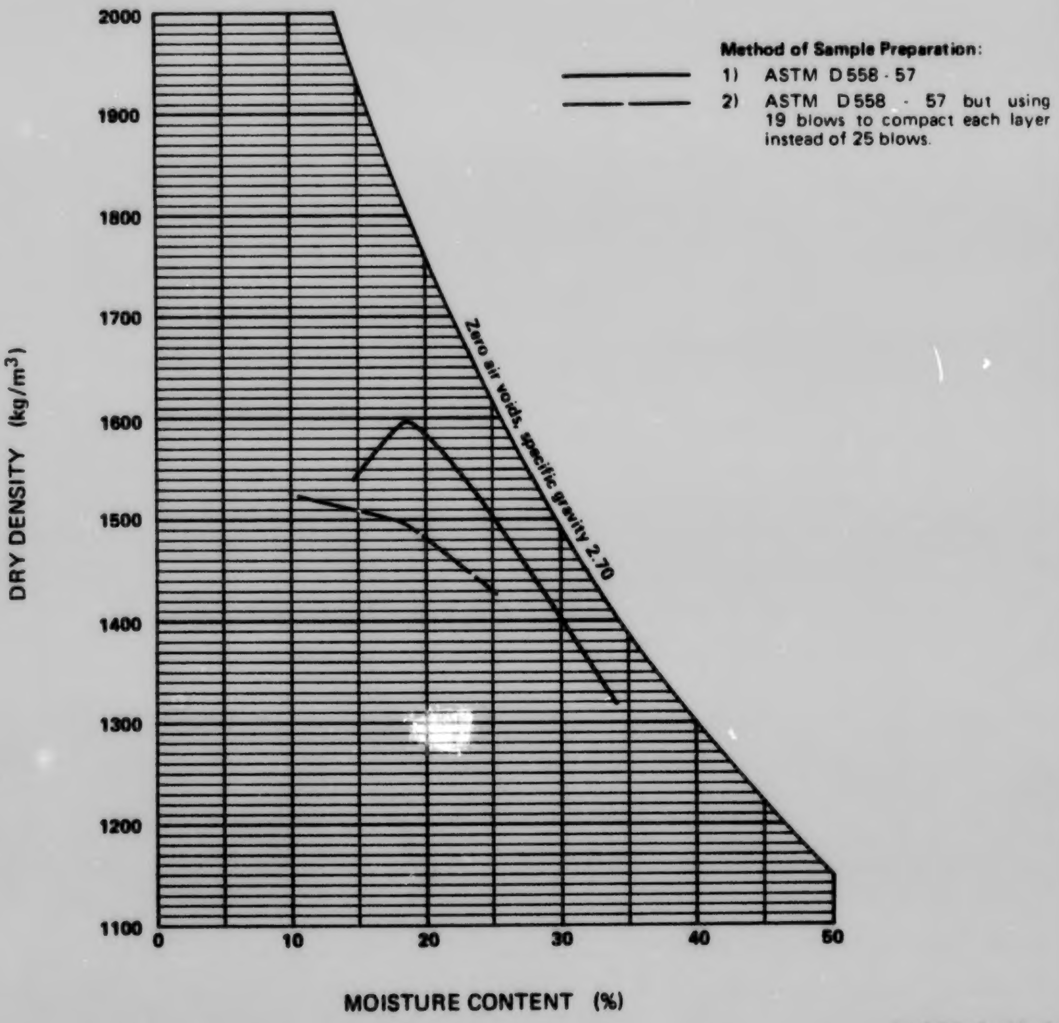
Stabilizer Dosage: FUJIBETON ______ %

Sample: Pincher Creek

FLYASH 13 %

Sand 16 %, Silt 46 %, Clay 38 %

CEMENT ______ %



SHEET 2 OF 2

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1SD83 - 00026

Project No.: 314 - 1264.02

Stabilizer Dosage: FUJIBETON 16 %

Sample: Pincher Creek

Sand 16%, Silt 46%, Clay 38%

FLYASH %

CEMENT %

TEST DATA:

1) Method of Sample Preparation: ASTM D 558 - 57

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	19.1	1529
2	24.4	1502
3	28.6	1470
4	33.0	1378
5	35.6	1307

Design Field Optimum Moisture Content: 25 %

Design Field Maximum Dry Density: 1500 kg/m³

2) Method of Sample Preparation: ASTM D558 - 57, but using 19 blows to compact each layer instead of 25 blows

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	18.4	1478
2	28.9	1470
3	28.6	1363
4	29.7	1419
5		

Design Field Optimum Moisture Content: 29 %

Design Field Maximum Dry Density: 1470 kg/m³

SHEET 1 OF 2

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

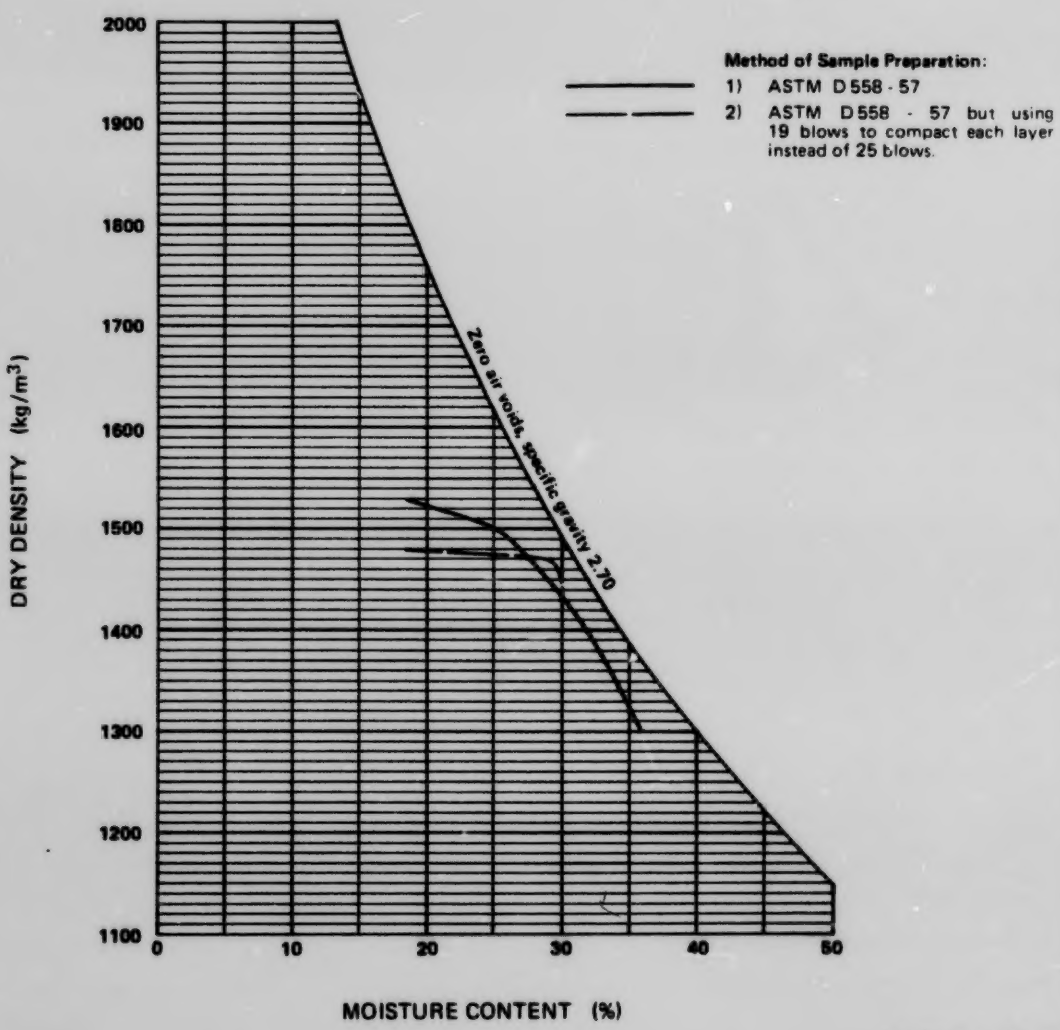
Stabilizer Dosage: FUJIBETON 16 %

FLYASH %

CEMENT %

Sample: Pincher Creek

Sand 16 %, Silt 46 %, Clay 38 %



SHEET 2 OF 2

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA Contract No.: 1SD83 - 00026

Project No.: 314 - 1264.02 Stabilizer Dosage: FUJIBETON ___ %

Sample: Pincher Creek FLYASH 7 %

Sand 16%, Silt 46%, Clay 38% CEMENT 3 %

TEST DATA:

1) Method of Sample Preparation: ASTM D 558 - 57

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m^3)
1	19.0	1496
2	24.0	1500
3	31.6	1288
4	34.0	1347
5	15.9	1491

Design Field Optimum Moisture Content: 21.1 %

Design Field Maximum Dry Density: 1538 kg/m^3

2) Method of Sample Preparation: ASTM D558 - 57, but using 19 blows to compact each layer instead of 25 blows

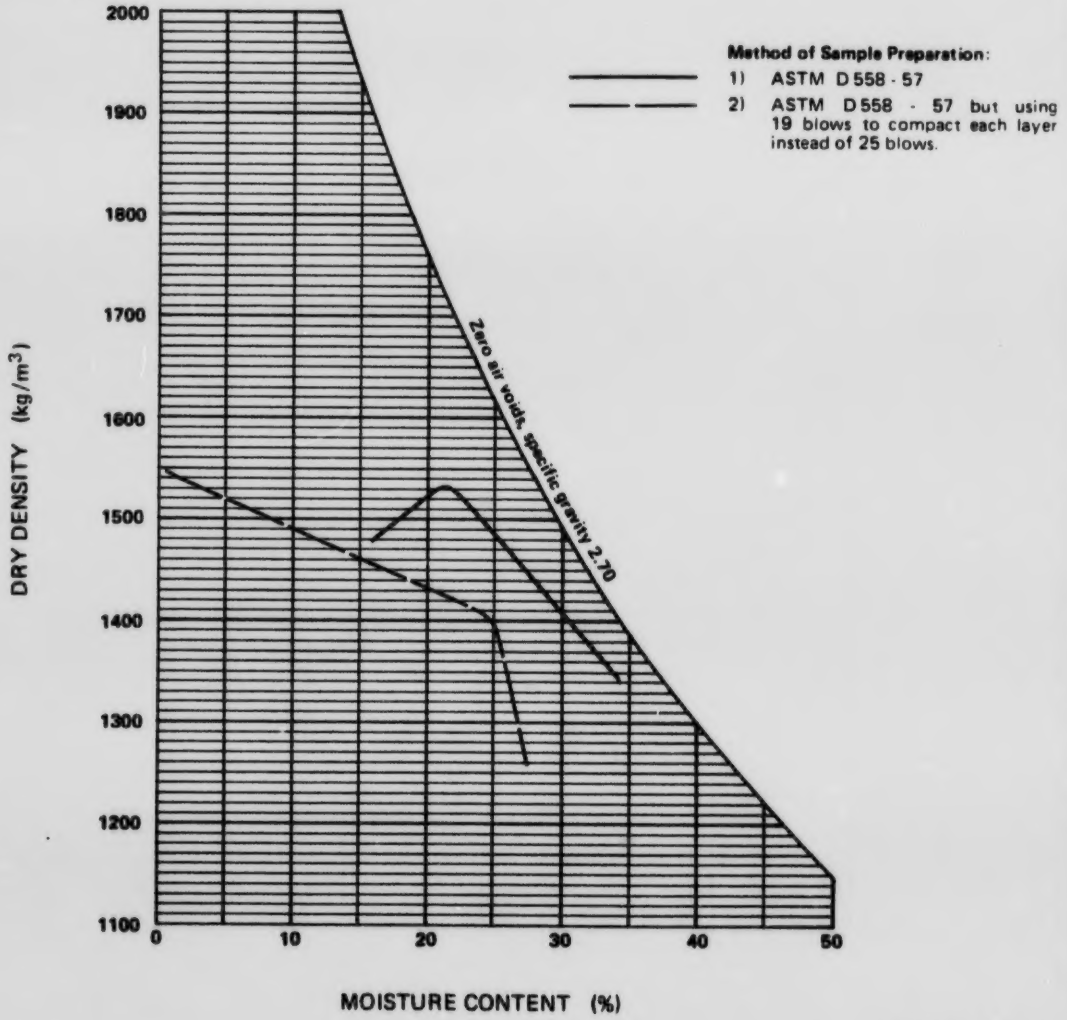
SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m^3)
1	0.0	1550
2	15.3	1464
3	25.5	1278
4	27.5	1277
5		

Design Field Optimum Moisture Content: 25 %

Design Field Maximum Dry Density: 1400 kg/m^3

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project:	Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers		
Client:	TRANSPORT CANADA	Contract No.:	1 SD 83 - 00026
Project No.:	314 - 1264.02	Stabilizer Dosage:	FUJIBETON ____ %
Sample:	Pincher Creek		FLYASH 7 %
	Sand 16 %, Silt 46 %, Clay 38 %		CEMENT 3 %



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Pincher Creek Initial Dry Density: 1381 kg/m^3

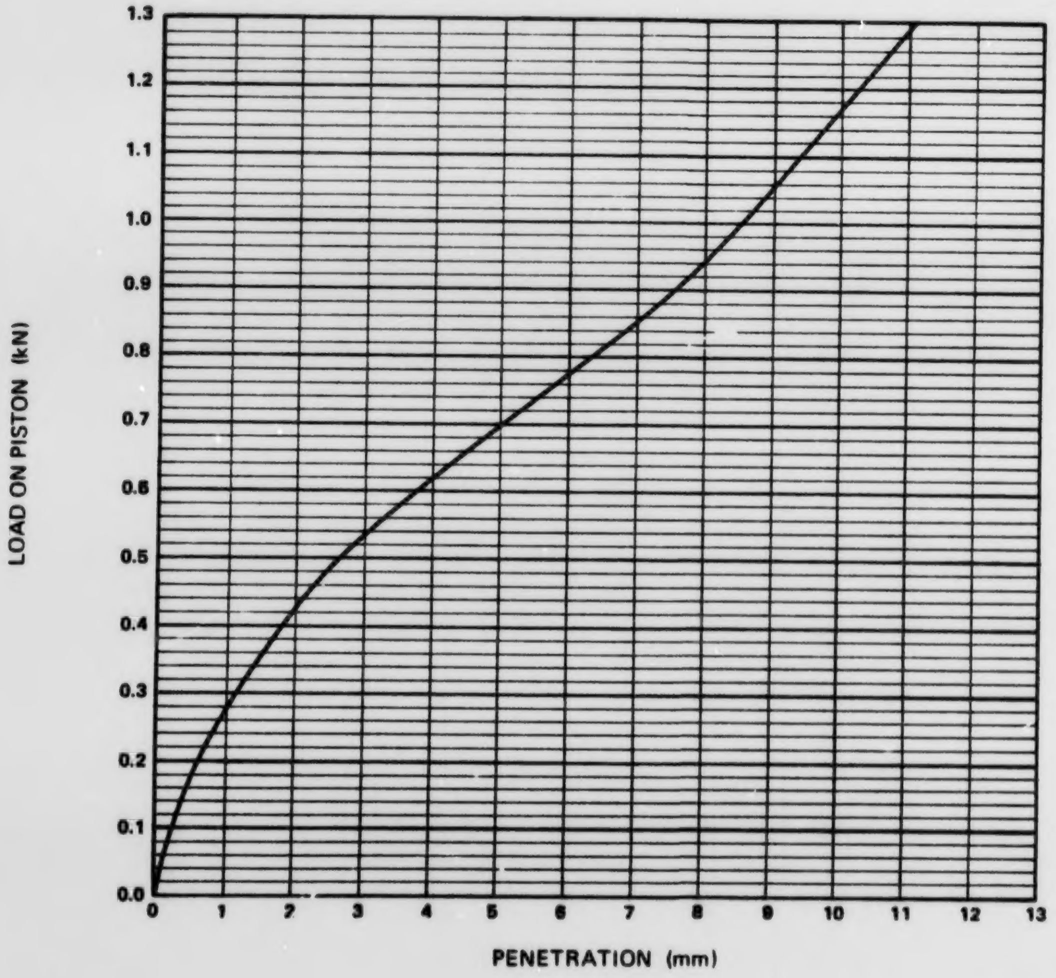
Sand 16%, Silt 46%, Clay 38% Initial Moisture Content: 31.9 %

Stabilizer Dosage: FUJIBETON 2 % Final Moisture Content: 30.2 %

FLYASH ______ % California Bearing Ratio: 2.5 mm 3.7 %

CEMENT ______ % 5.0 mm 3.5 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 100% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Pincher Creek

Sand 16% , Silt 46% , Clay 38%

Initial Dry Density: 1497.7 kg/m^3

Initial Moisture Content: 23.3 %

Stabilizer Dosage: FUJIBETON 2 %

Final Moisture Content: 31.9 %

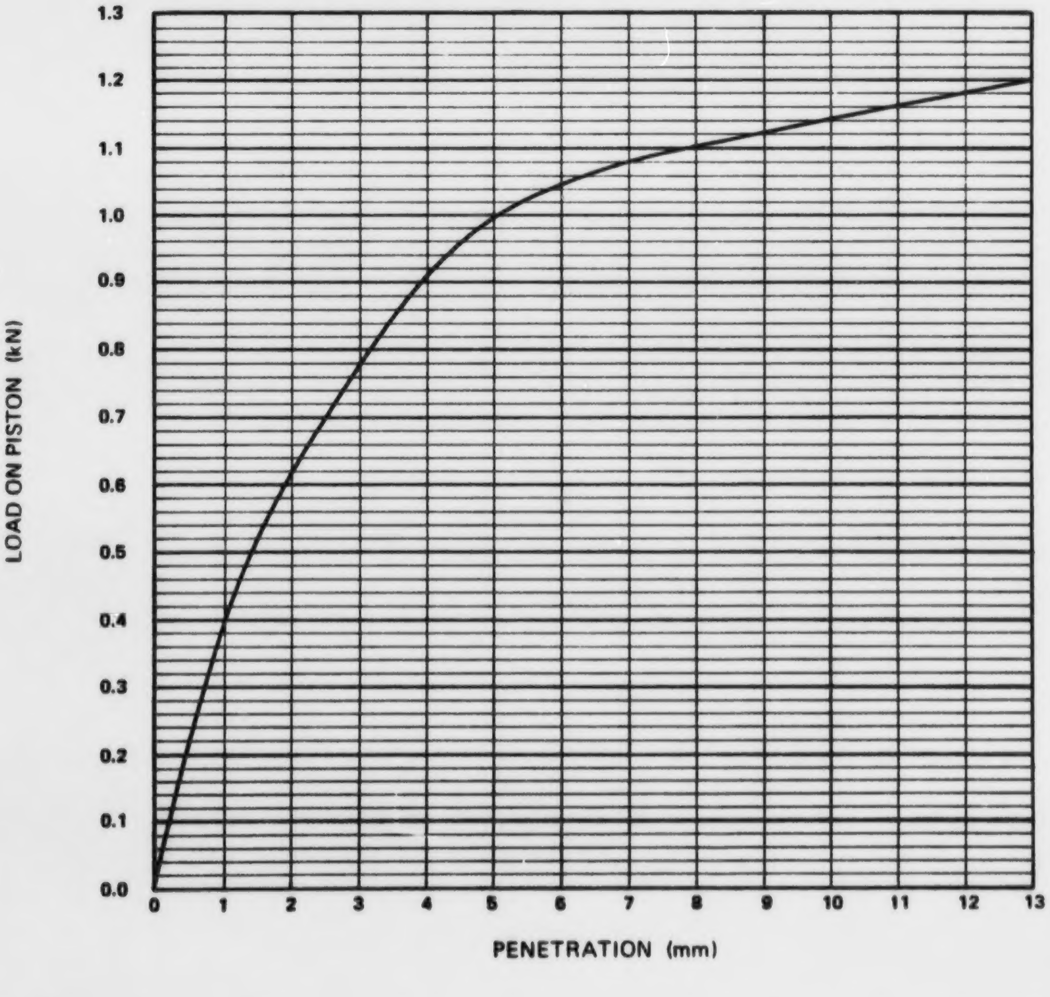
FLYASH %

California Bearing Ratio: 2.5 mm 5.2 %

CEMENT %

5.0 mm 5.0 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 75% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Pincher Creek

Sand 16%, Silt 46%, Clay 38%

Initial Dry Density: 1428 kg/m^3

Initial Moisture Content: 30.6 %

Stabilizer Dosage: FUJIBETON 4 %

Final Moisture Content: 34.5 %

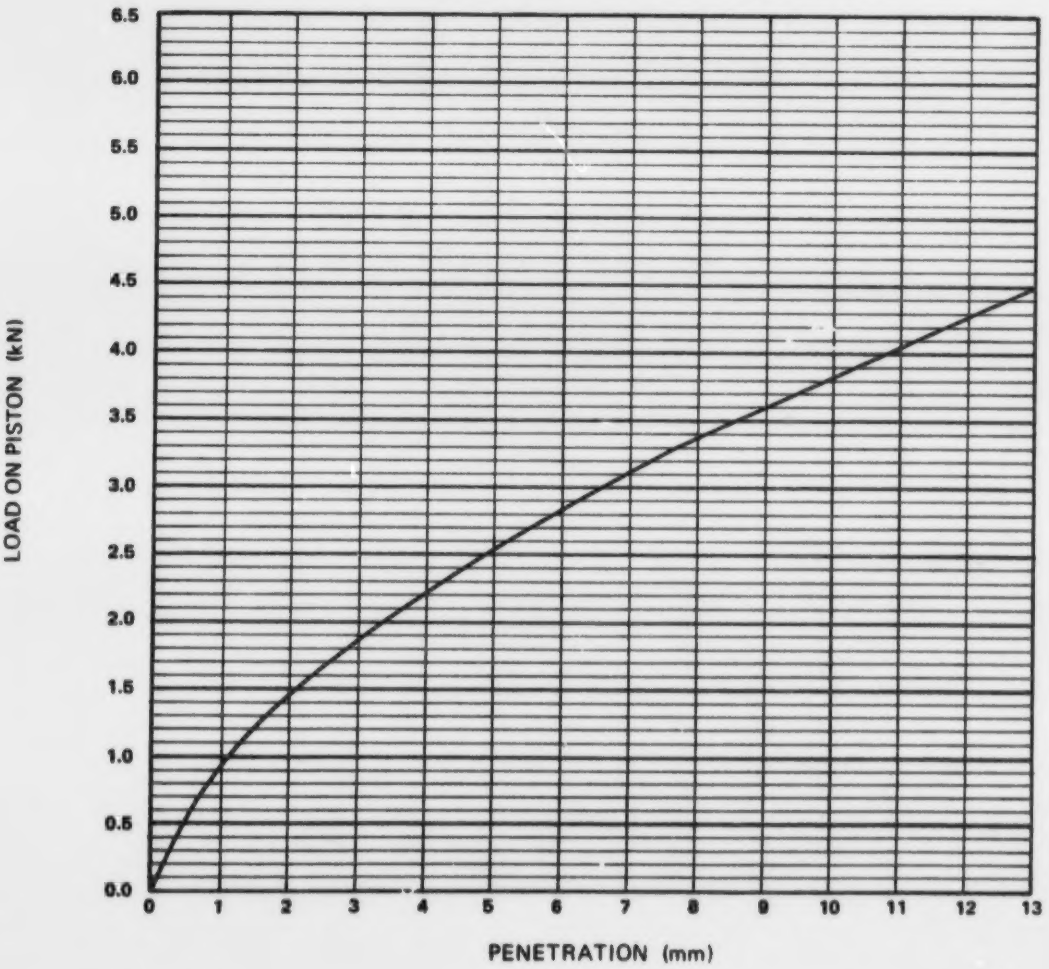
FLYASH %

California Bearing Ratio: 2.5 mm 13 %

CEMENT %

5.0 mm 13 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 100% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Pincher Creek

Sand 16% , Silt 46% , Clay 38%

Initial Dry Density: 1369.5 kg/m^3

Initial Moisture Content: 32.1 %

Stabilizer Dosage: FUJIBETON 4 %

Final Moisture Content: 36.2 %

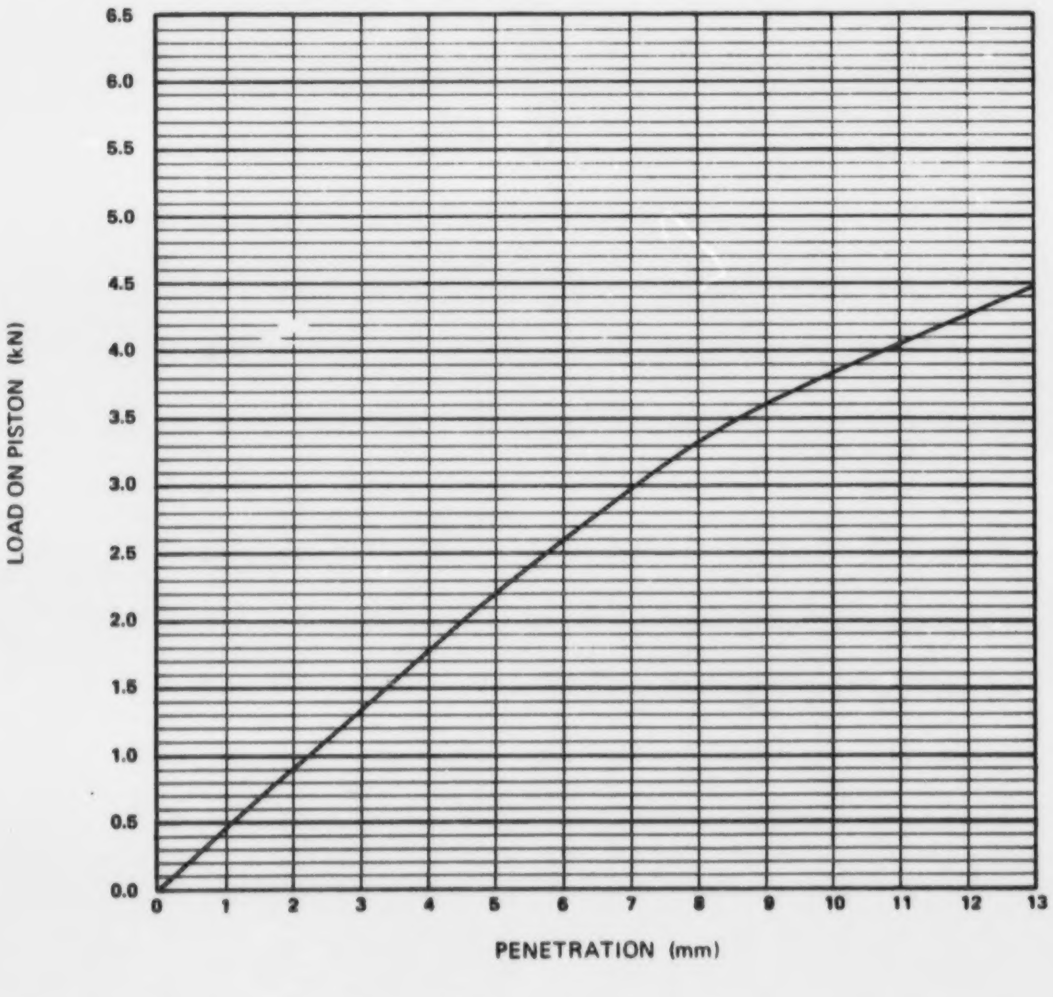
FLYASH %

California Bearing Ratio: 2.5 mm 8.2 %

CEMENT %

5.0 mm 11.0 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 75% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Pincher Creek

Sand 16%, Silt 46%, Clay 38%

Initial Dry Density: 1498 kg/m^3

Initial Moisture Content: 18.6 %

Stabilizer Dosage: FUJIBETON 7 %

Final Moisture Content: 26.7 %

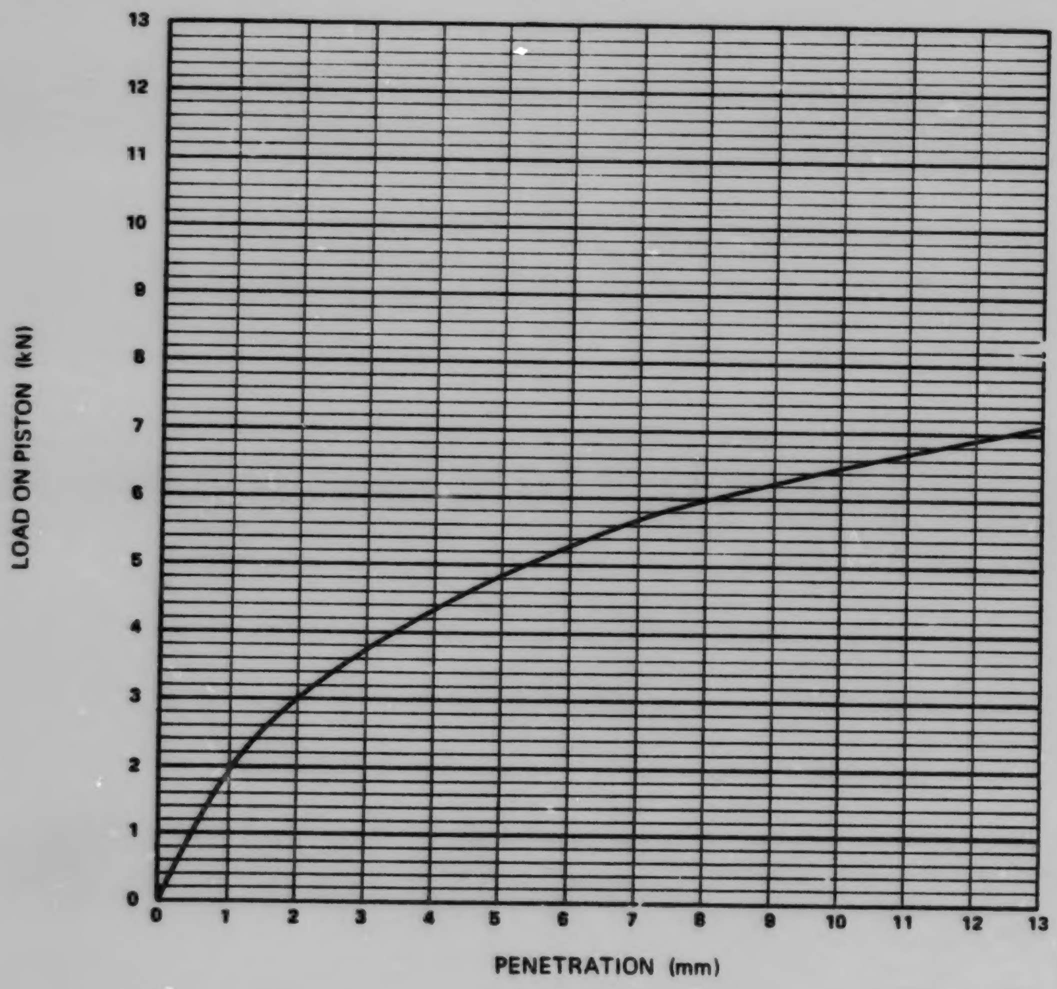
FLYASH %

California Bearing Ratio: 2.5 mm 26 %

CEMENT %

5.0 mm 24 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 100% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 · 00026

Project No.: 314 · 1264.02

Sample: Pincher Creek

Sand 16%, Silt 46%, Clay 38%

Initial Dry Density: 1462.4 kg/m^3

Initial Moisture Content: 25.9 %

Stabilizer Dosage: FUJIBETON 7 %

Final Moisture Content: 24.5 %

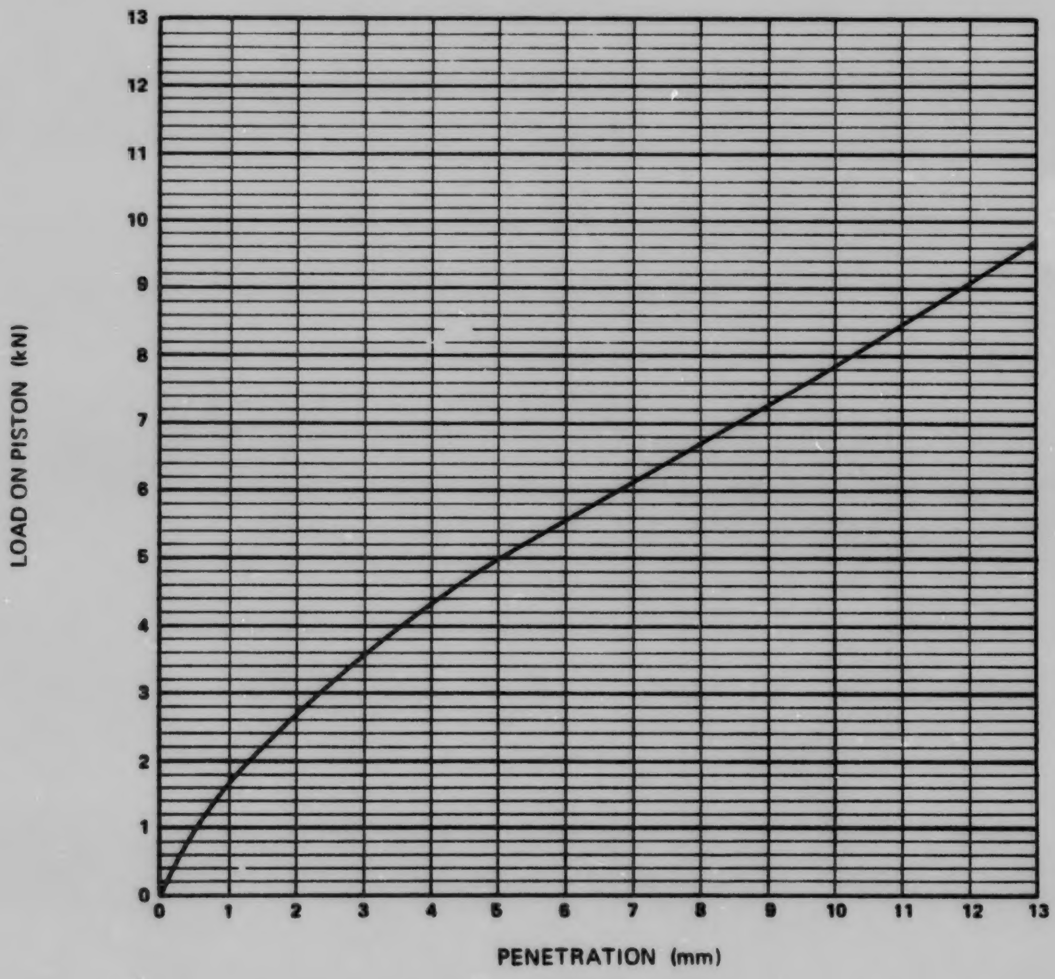
FLYASH %

California Bearing Ratio: 2.5 mm 24 %

CEMENT %

5.0 mm 25 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 75% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA
Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Pincher Creek
Initial Dry Density: 1499 kg/m^3

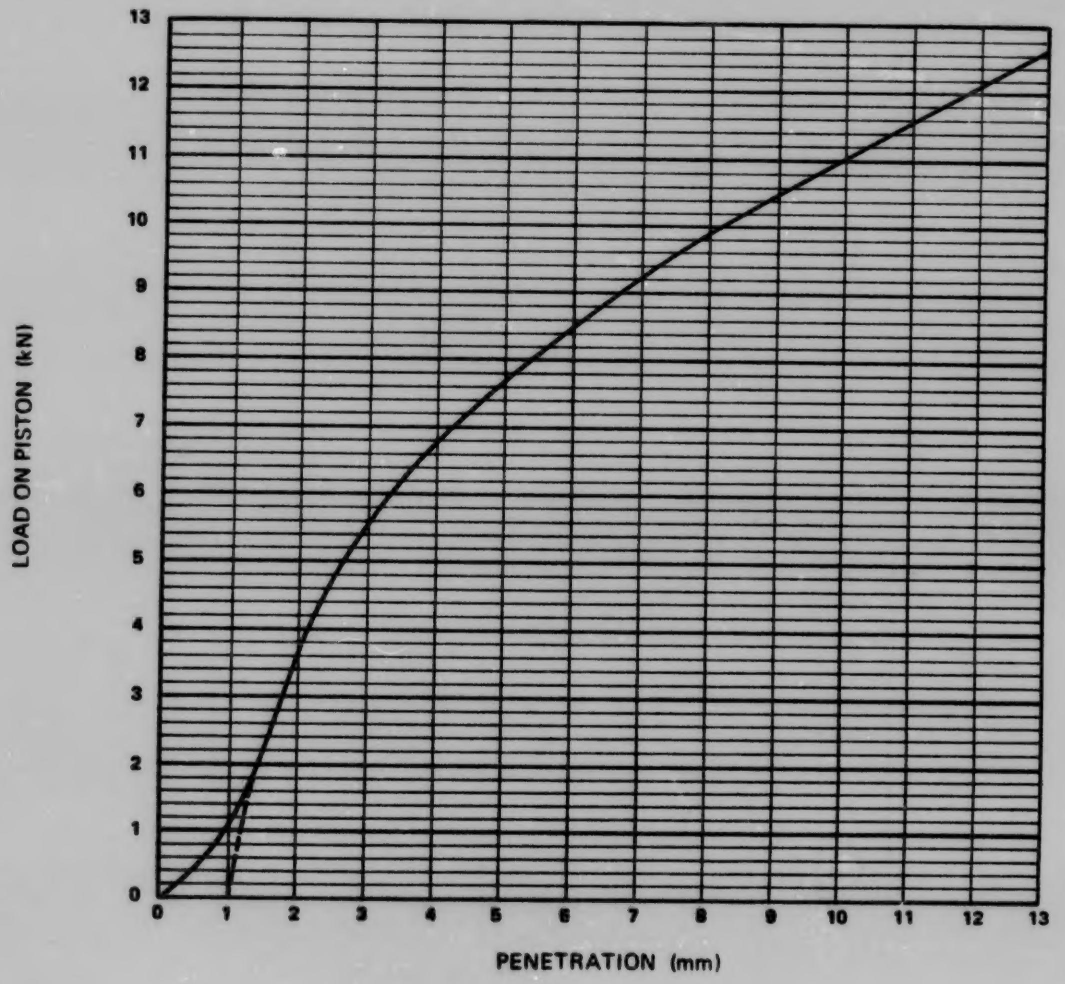
Sand 16%, Silt 46%, Clay 38%
Initial Moisture Content: 26.0 %

Stabilizer Dosage: FUJIBETON 9 %
Final Moisture Content: 25.0 %

FLYASH %
California Bearing Ratio: 2.5 mm 47 %

CEMENT %
5.0 mm 42 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 100% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Pincher Creek

Sand 16% , Silt 46% , Clay 38%

Initial Dry Density: 1438.4 kg/m^3

Initial Moisture Content: 25.9 %

Stabilizer Dosage: FUJIBETON 9 %

Final Moisture Content: 27.5 %

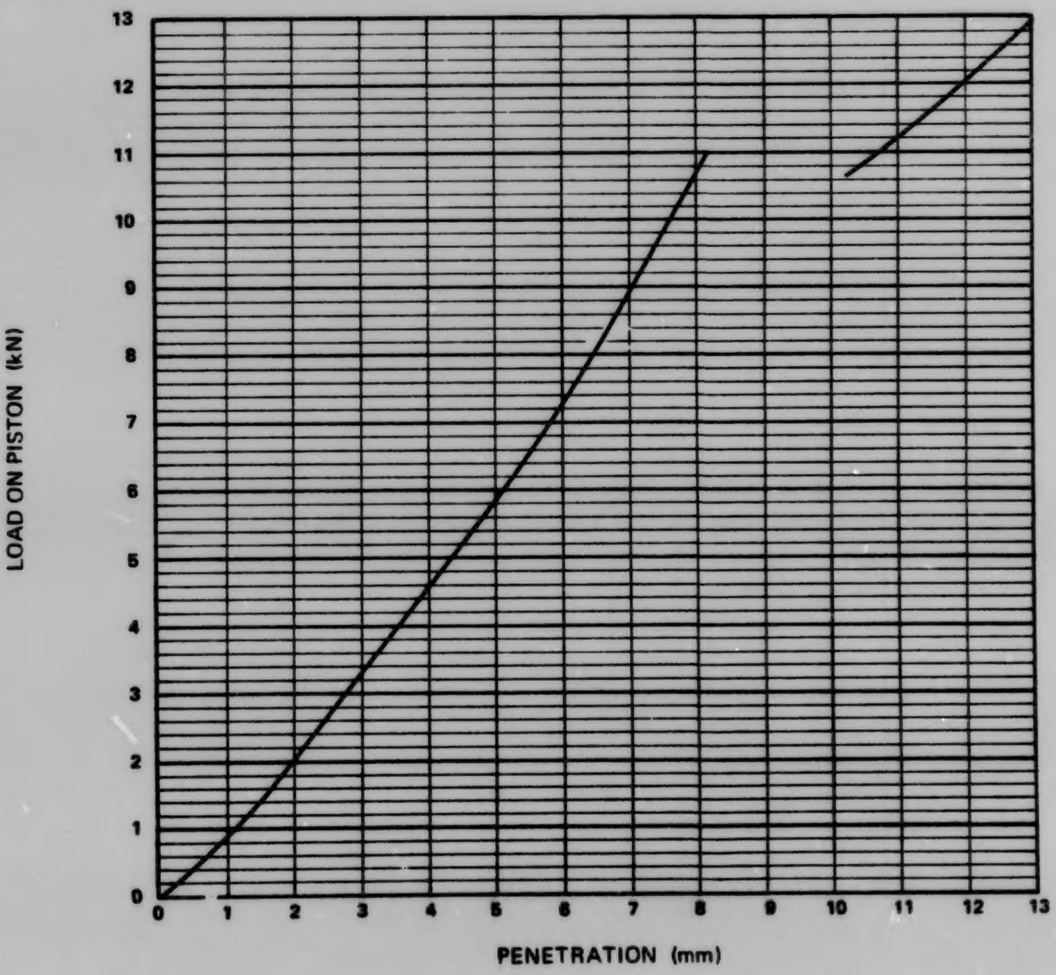
FLYASH %

California Bearing Ratio: 2.5 mm 21 %

CEMENT %

5.0 mm 30 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 75% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Pincher Creek

Sand 16% , Silt 46% , Clay 38%

Initial Dry Density: 1492 kg/m^3

Initial Moisture Content: 20.9 %

Stabilizer Dosage: FUJIBETON 12 %

Final Moisture Content: 22.8 %

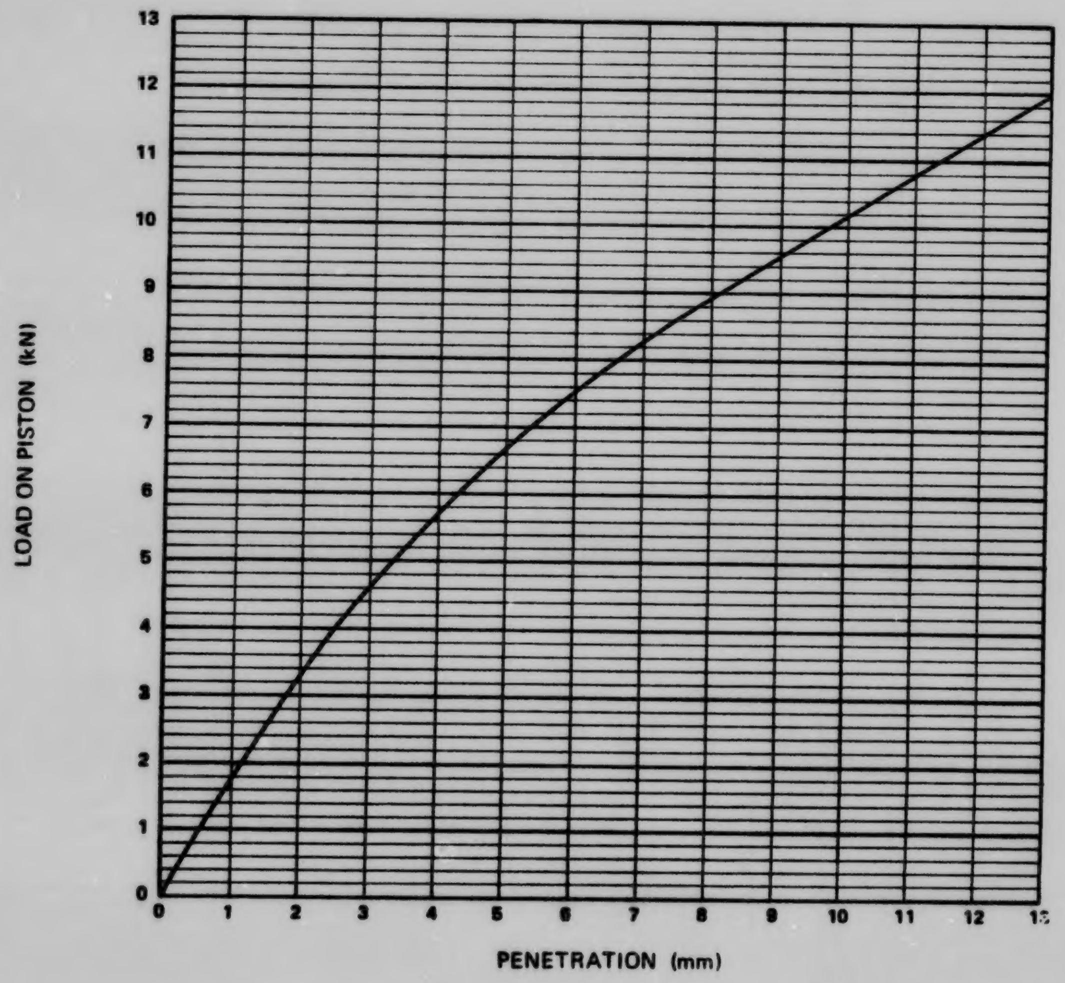
FLYASH %

California Bearing Ratio: 2.5 mm 31 %

CEMENT %

5.0 mm 33 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 100% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Pincher Creek

Sand 16%, Silt 46%, Clay 38%

Initial Dry Density: 1417.6 kg/m^3

Initial Moisture Content: 30.4 %

Stabilizer Dosage: FUJIBETON 12 %

Final Moisture Content: 28.9 %

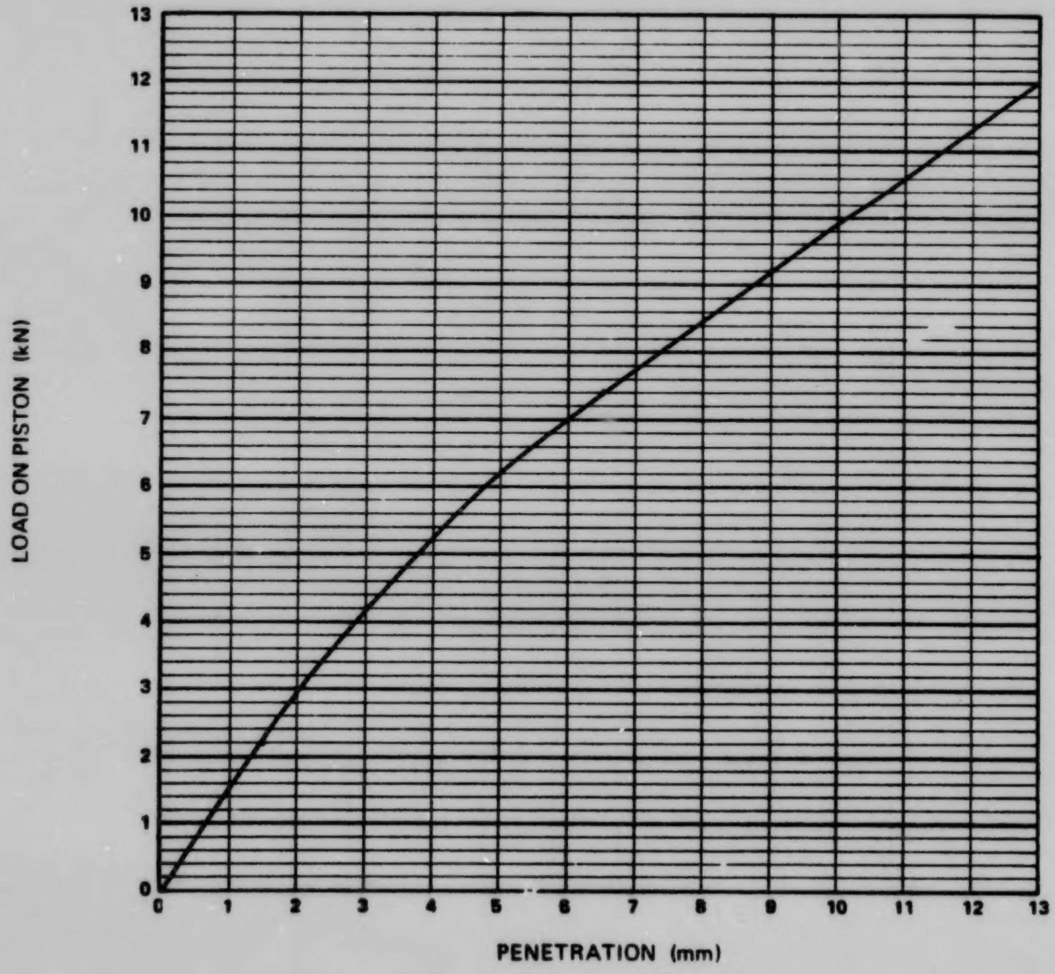
FLYASH %

California Bearing Ratio: 2.5 mm 27 %

CEMENT %

5.0 mm 31 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 75% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Pincher Creek

Sand 16%, Silt 46%, Clay 38%

Initial Dry Density: 1443 kg/m^3

Initial Moisture Content: 29.9 %

Stabilizer Dosage: FUJIBETON 16 %

Final Moisture Content: 30.7 %

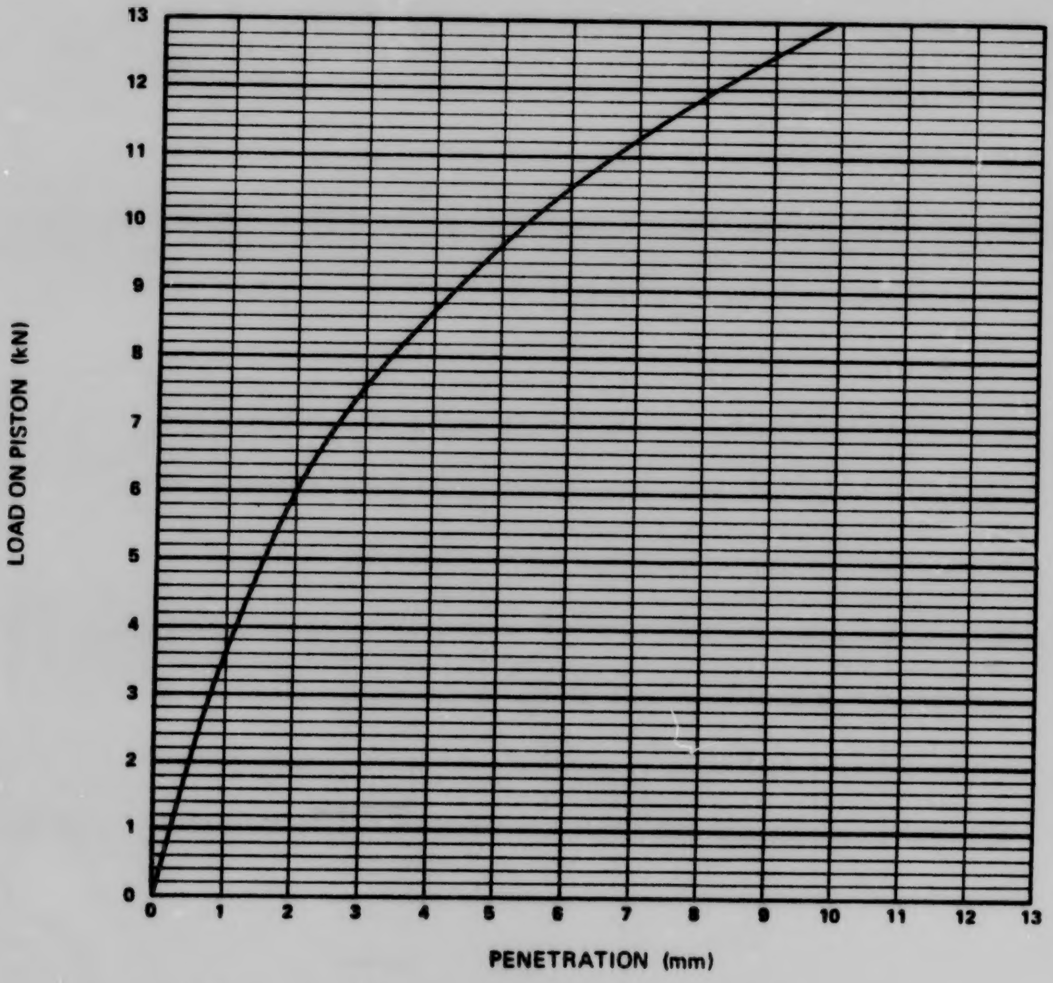
FLYASH %

California Bearing Ratio: 2.5 mm 53 %

CEMENT %

5.0 mm 48 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 100% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Pincher Creek

Sand 16%, Silt 46%, Clay 38%

Initial Dry Density: 1505.7 kg/m^3

Initial Moisture Content: 26.0 %

Stabilizer Dosage: FUJIBETON 16 %

FLYASH %

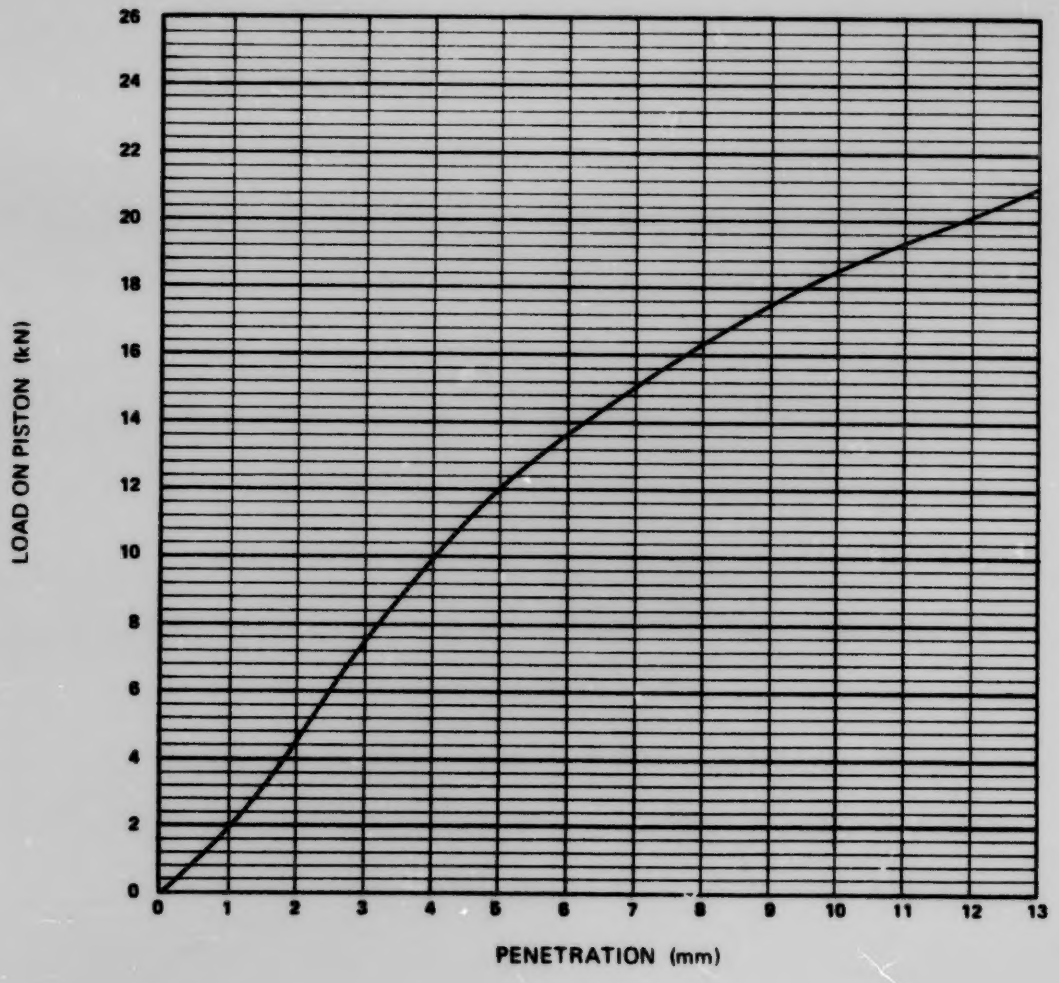
CEMENT %

Final Moisture Content: 33.6 %

California Bearing Ratio: 2.5 mm 46 %

5.0 mm 60 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 75% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



EBA Engineering Consultants Ltd.

eba

CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 · 00026

Project No.: 314 · 1264.02

Sample: Pincher Creek

Sand 16% , Silt 46% , Clay 38%

Initial Dry Density: 1476 kg/m^3

Initial Moisture Content: 30.1 %

Final Moisture Content: 28.8 %

Stabilizer Dosage: FUJIBETON %

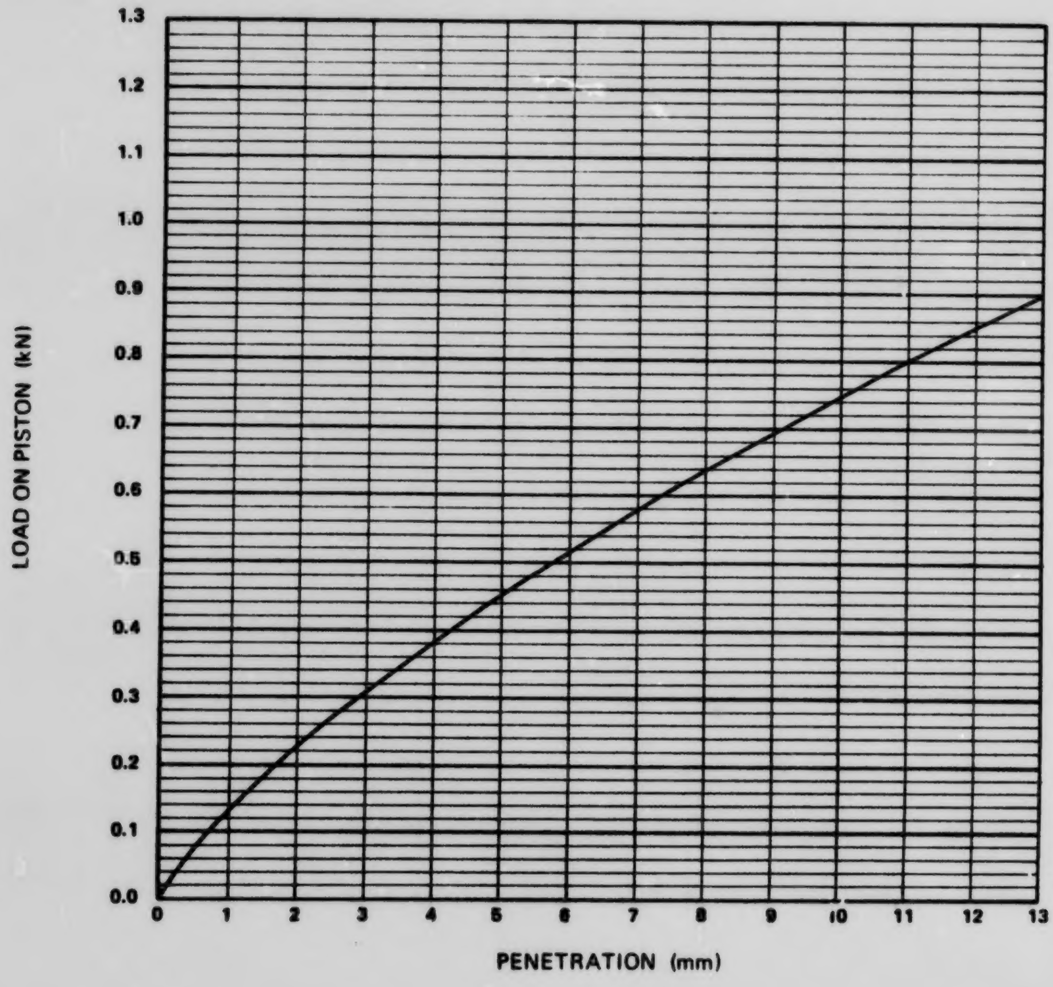
FLYASH 2 %

CEMENT %

California Bearing Ratio: 2.5 mm 2.0 %

5.0 mm 2.2 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 100% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 · 00026

Project No.: 314 · 1264.02

Sample: Pincher Creek

Sand 16%, Silt 46%, Clay 38%

Initial Dry Density: 1447 kg/m^3

Initial Moisture Content: 24.8 %

Stabilizer Dosage: FUJIBETON ____ %

FLYASH 2 %

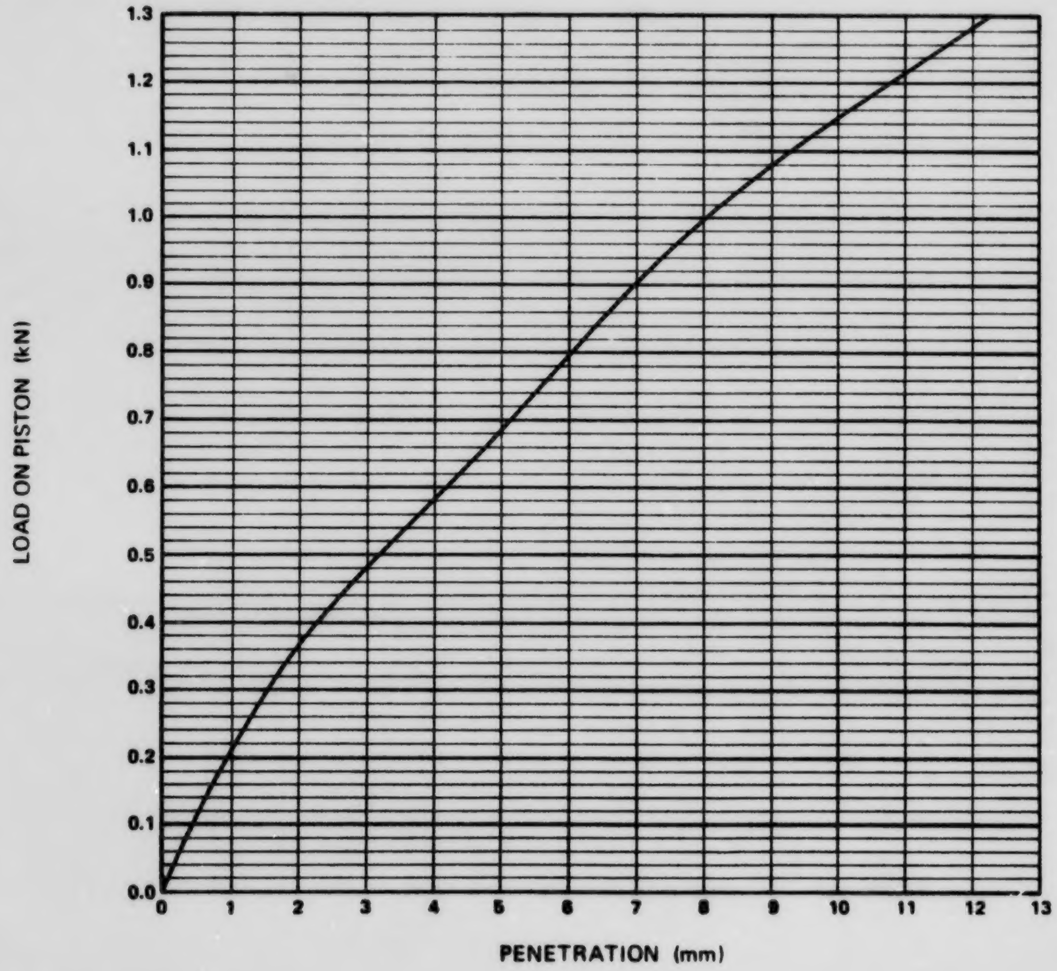
CEMENT ____ %

Final Moisture Content: 25.7 %

California Bearing Ratio: 2.5 mm 3.1 %

5.0 mm 3.3 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 75% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 · 00026

Project No.: 314 · 1264.02

Sample: Pincher Creek

Sand 16% , Silt 46% , Clay 38%

Initial Dry Density: 1505 kg/m^3

Initial Moisture Content: 25.4 %

Stabilizer Dosage: FUJIBETON ___ %

FLYASH 6 %

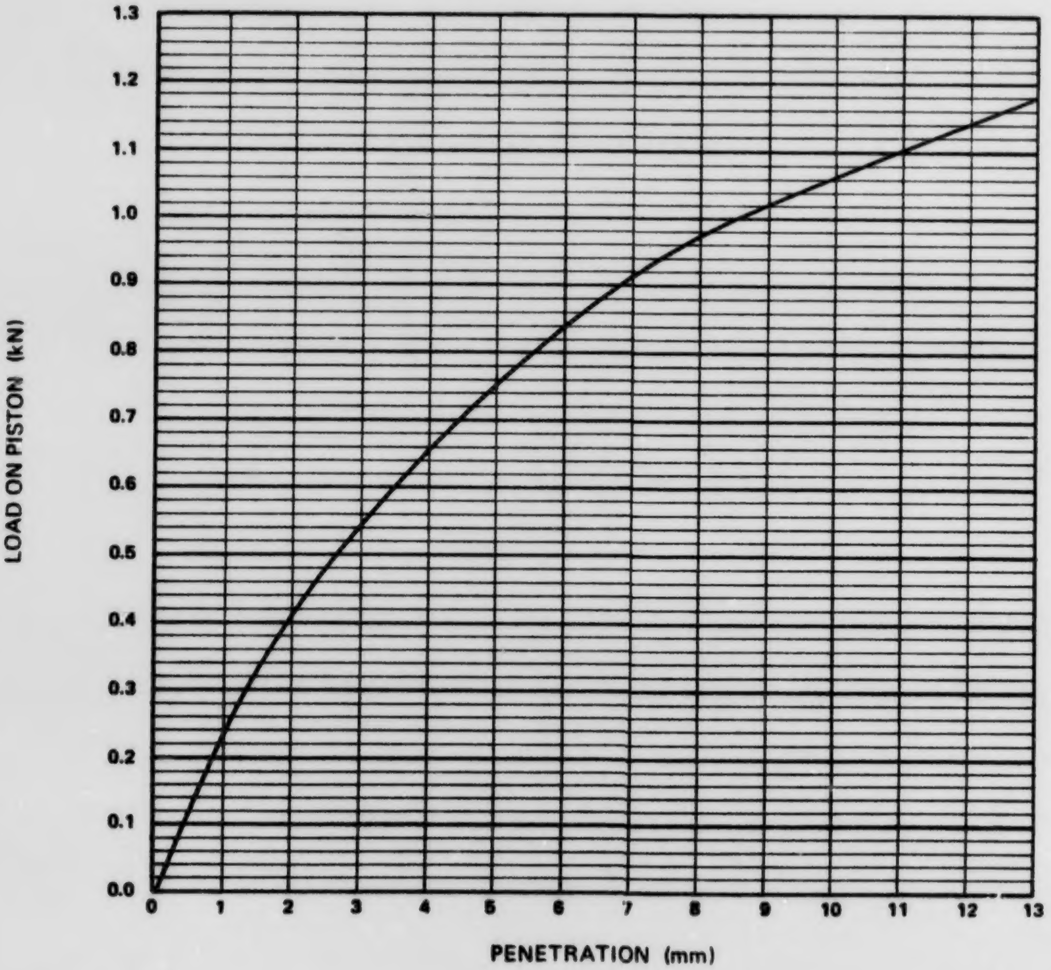
CEMENT ___ %

Final Moisture Content: 26.0 %

California Bearing Ratio: 2.5 mm 3.4 %

5.0 mm 3.7 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 100% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Pincher Creek

Sand 16% , Silt 46% , Clay 38%

Initial Dry Density: 1412 kg/m^3

Initial Moisture Content: 31.7 %

Stabilizer Dosage: FUJIBETON ____ %

FLYASH 6 %

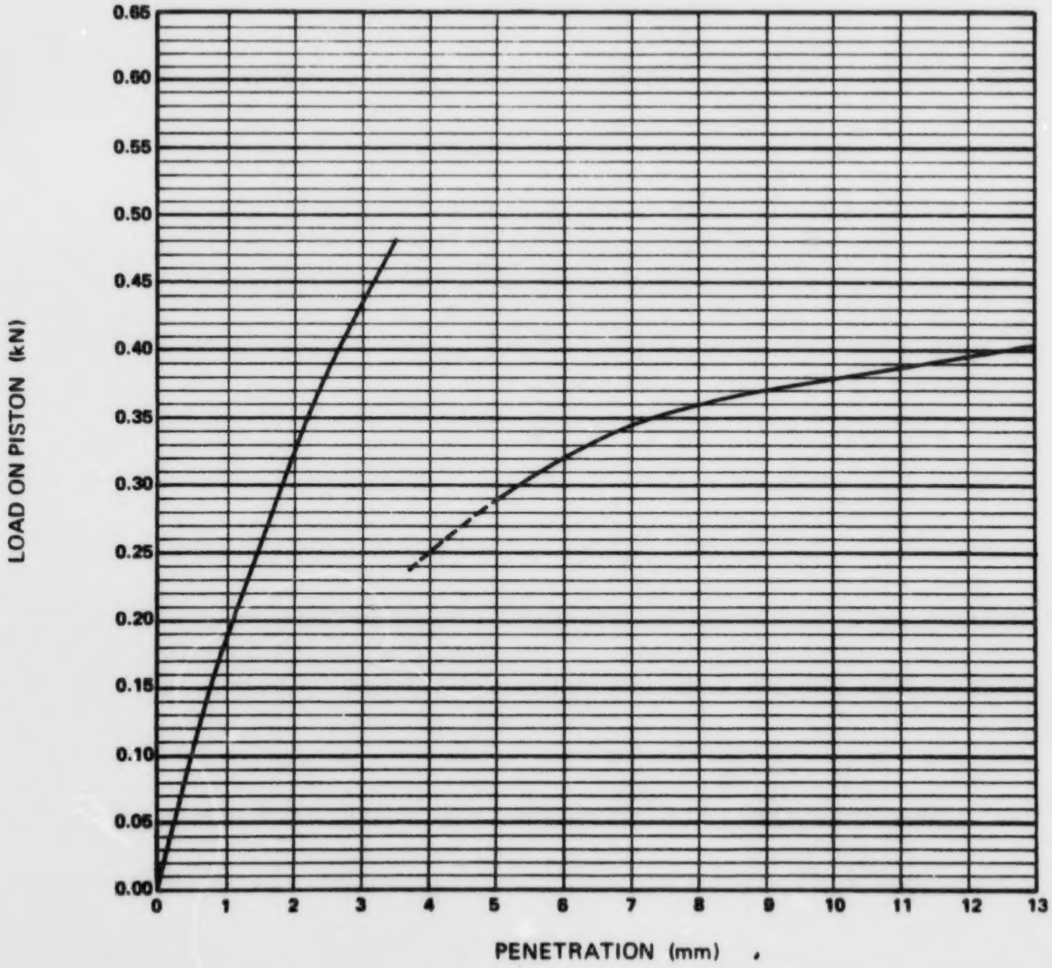
CEMENT ____ %

Final Moisture Content: 32.5 %

California Bearing Ratio: 2.5 mm 2.9 %

5.0 mm ____

Sample statically compacted to maximum dry density obtained during compaction test performed using 75% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 · 00026

Project No.: 314 · 1264.02

Sample: Pincher Creek

Sand 16%, Silt 46%, Clay 38%

Initial Dry Density: 1480 kg/m^3

Initial Moisture Content: 27.2 %

Stabilizer Dosage: FUJIBETON ___ %

FLYASH 10 %

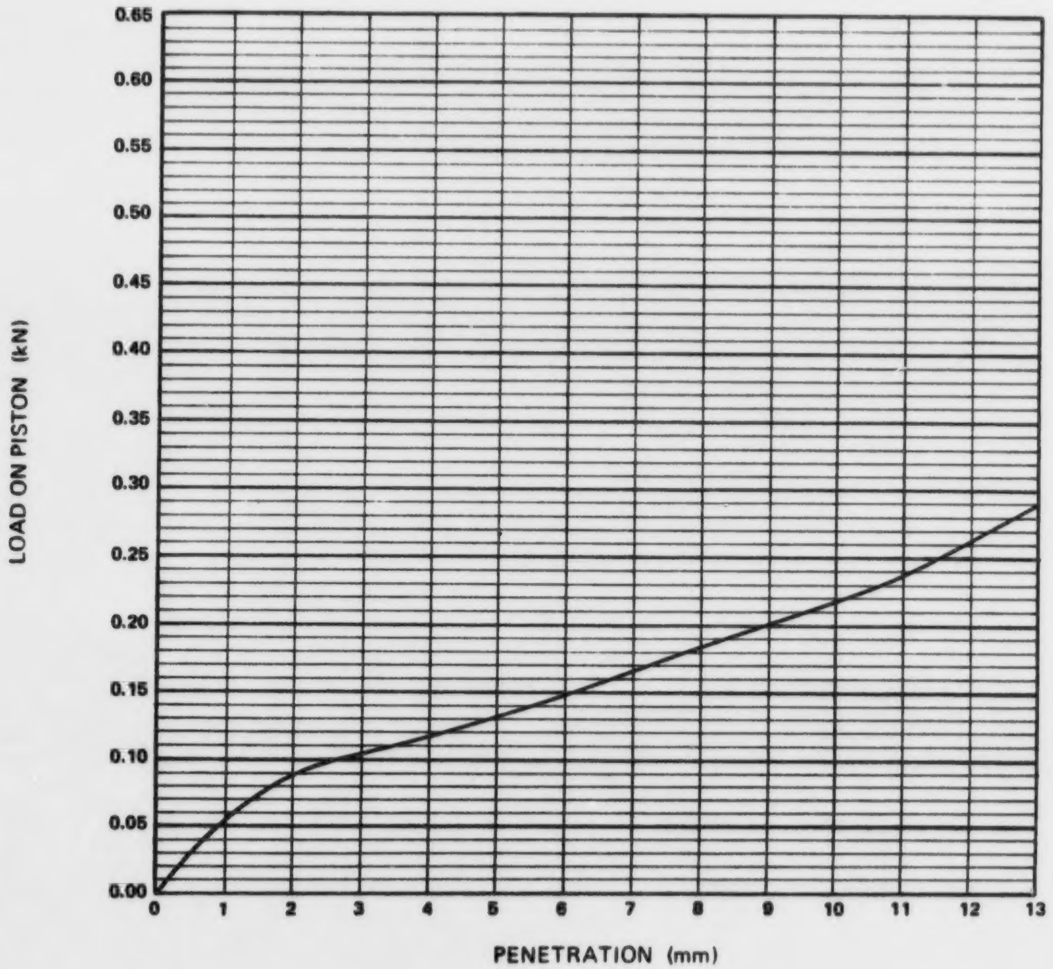
CEMENT ___ %

Final Moisture Content: 37.5 %

California Bearing Ratio: 2.5 mm 0.8 %

5.0 mm 0.7 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 100% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 · 00026

Project No.: 314 · 1264.02

Sample: Pincher Creek

Sand 16% , Silt 46% , Clay 38%

Initial Dry Density: 1494 kg/m^3

Initial Moisture Content: 20.2 %

Final Moisture Content: 34.0 %

Stabilizer Dosage: FUJIBETON ____ %

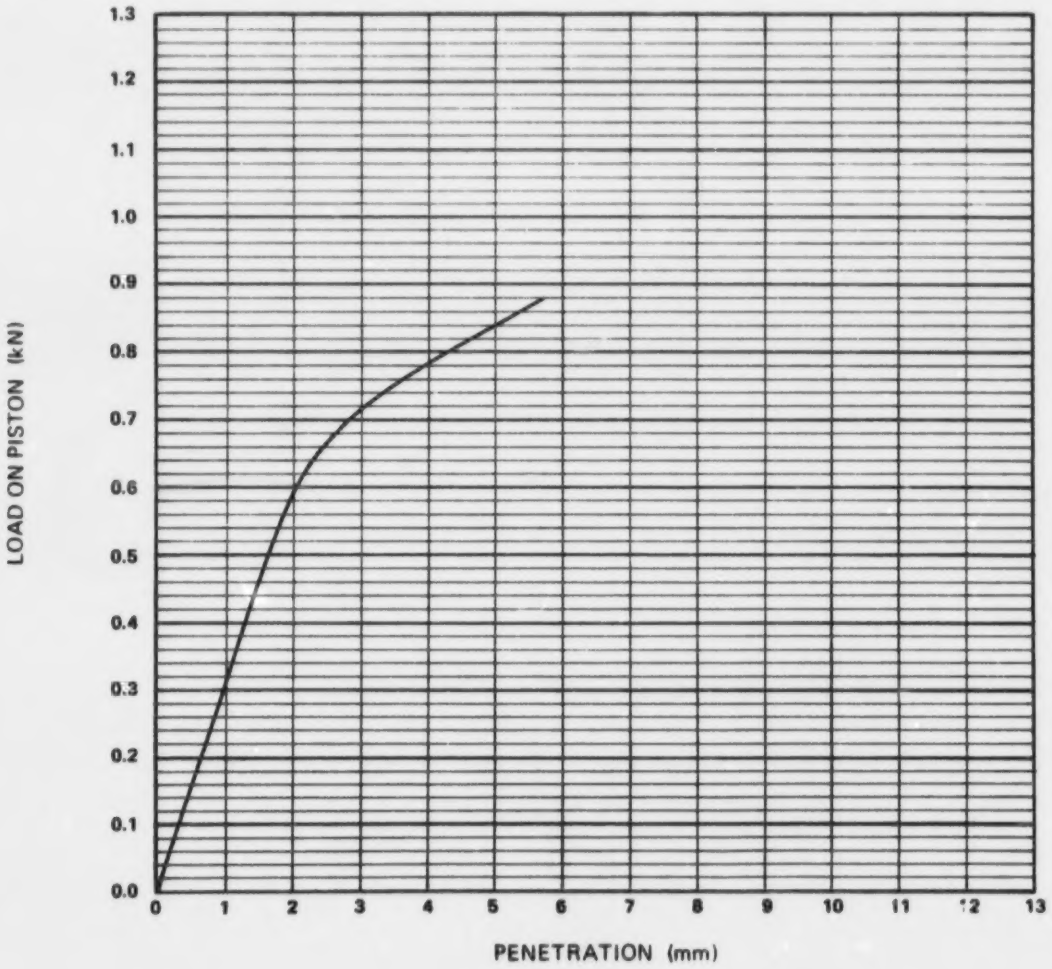
FLYASH 10 %

CEMENT ____ %

California Bearing Ratio: 2.5 mm ____

5.0 mm ____

Sample statically compacted to maximum dry density obtained during compaction test performed using 75% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Pincher Creek

Sand 16%, Silt 46%, Clay 38%

Initial Dry Density: 1536 kg/m^3

Initial Moisture Content: 23.6 %

Stabilizer Dosage: FUJIBETON ____ %

Final Moisture Content: 34.9 %

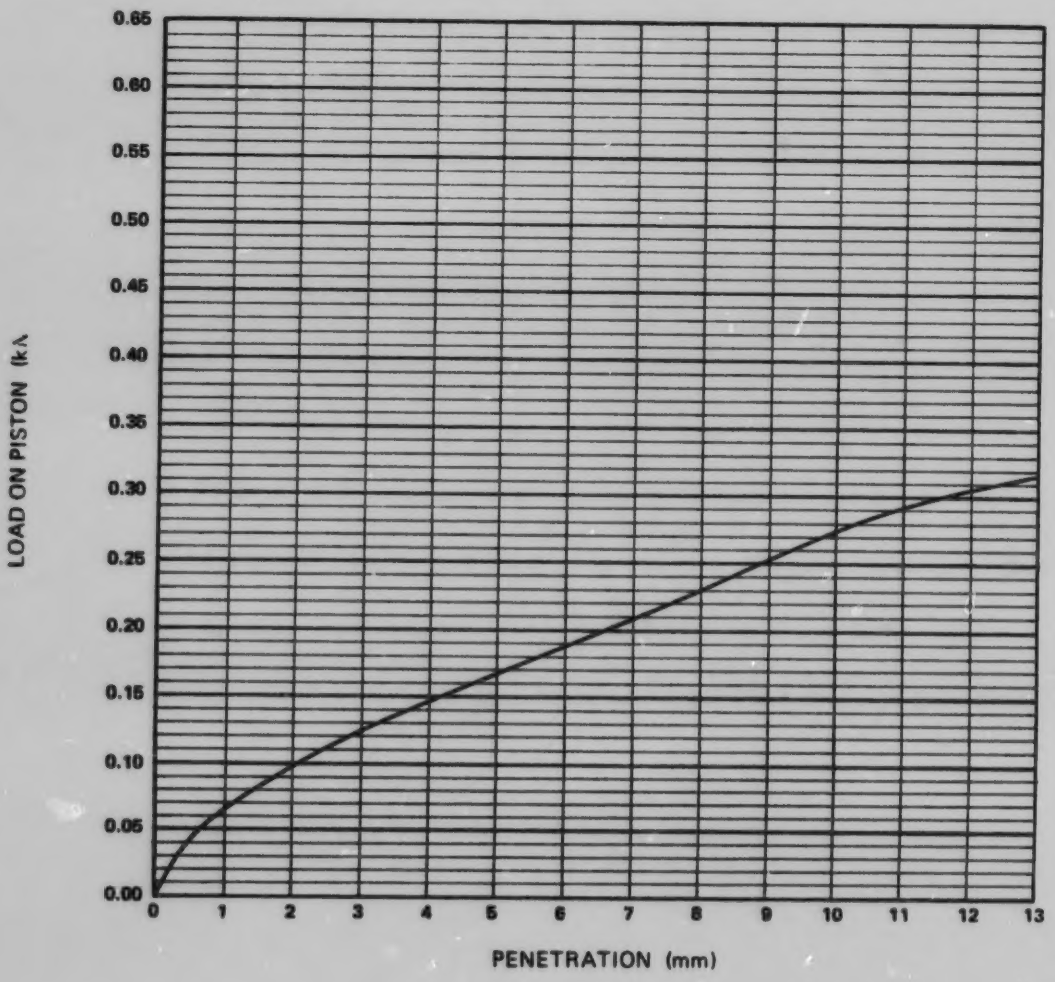
FLYASH 13 %

California Bearing Ratio: 2.5 mm 0.8 %

CEMENT ____ %

5.0 mm 0.8 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 100% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Pincher Creek

Sand 16%, Silt 46%, Clay 38%

Initial Dry Density: 1499 kg/m^3

Initial Moisture Content: 18.1 %

Stabilizer Dosage: FUJIBETON %

Final Moisture Content: 35.4 %

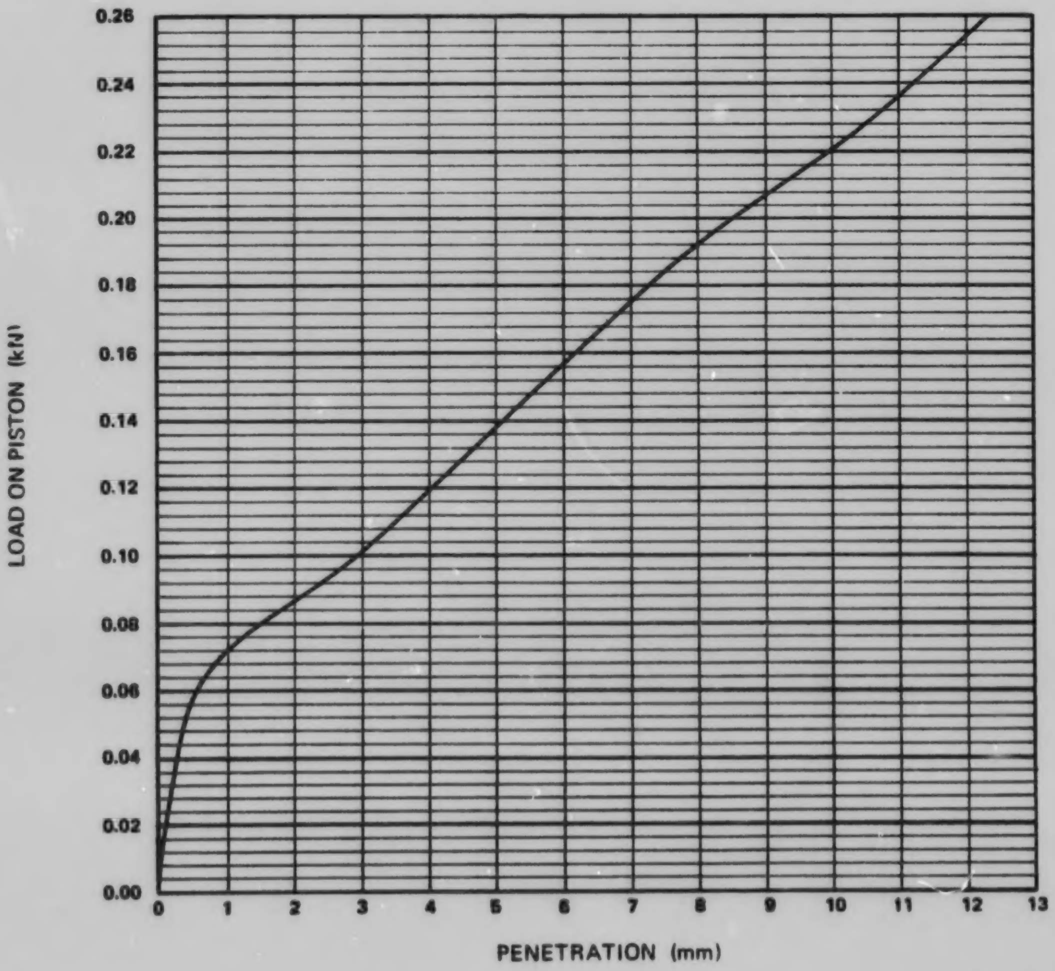
FLYASH 13 %

California Bearing Ratio: 2.5 mm 0.70 %

CEMENT %

5.0 mm 0.69 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 75% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Pincher Creek

Sand 16%, Silt 46%, Clay 38%

Initial Dry Density: 1598 kg/m^3

Initial Moisture Content: 25.9 %

Stabilizer Dosage: FUJIBETON ____ %

Final Moisture Content: 36.0 %

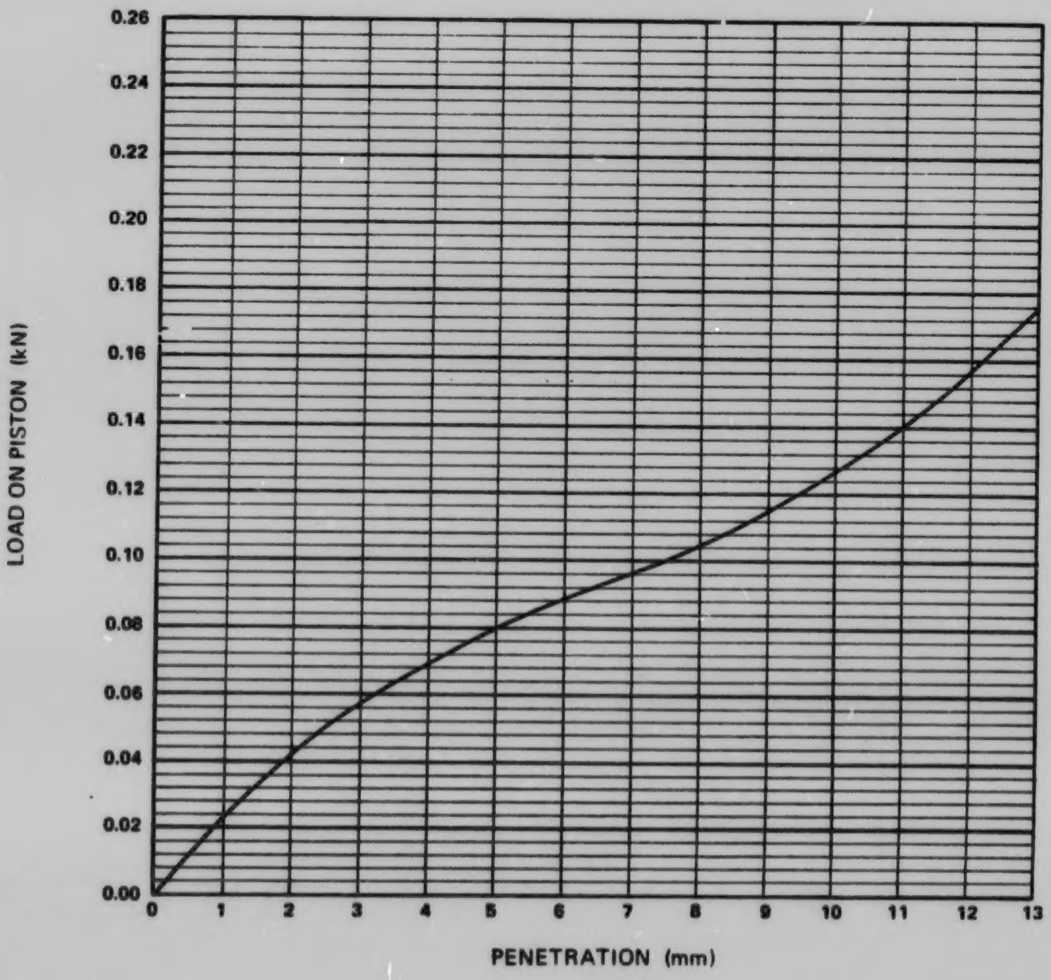
FLYASH 16 %

California Bearing Ratio: 2.5 mm 0.4 %

CEMENT ____ %

5.0 mm 0.4 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 100% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Pincher Creek

Sand 16% , Silt 46% , Clay 38%

Initial Dry Density: 1433 kg/m^3

Initial Moisture Content: 22.9 %

Stabilizer Dosage: FUJIBETON ______ %

FLYASH 16 %

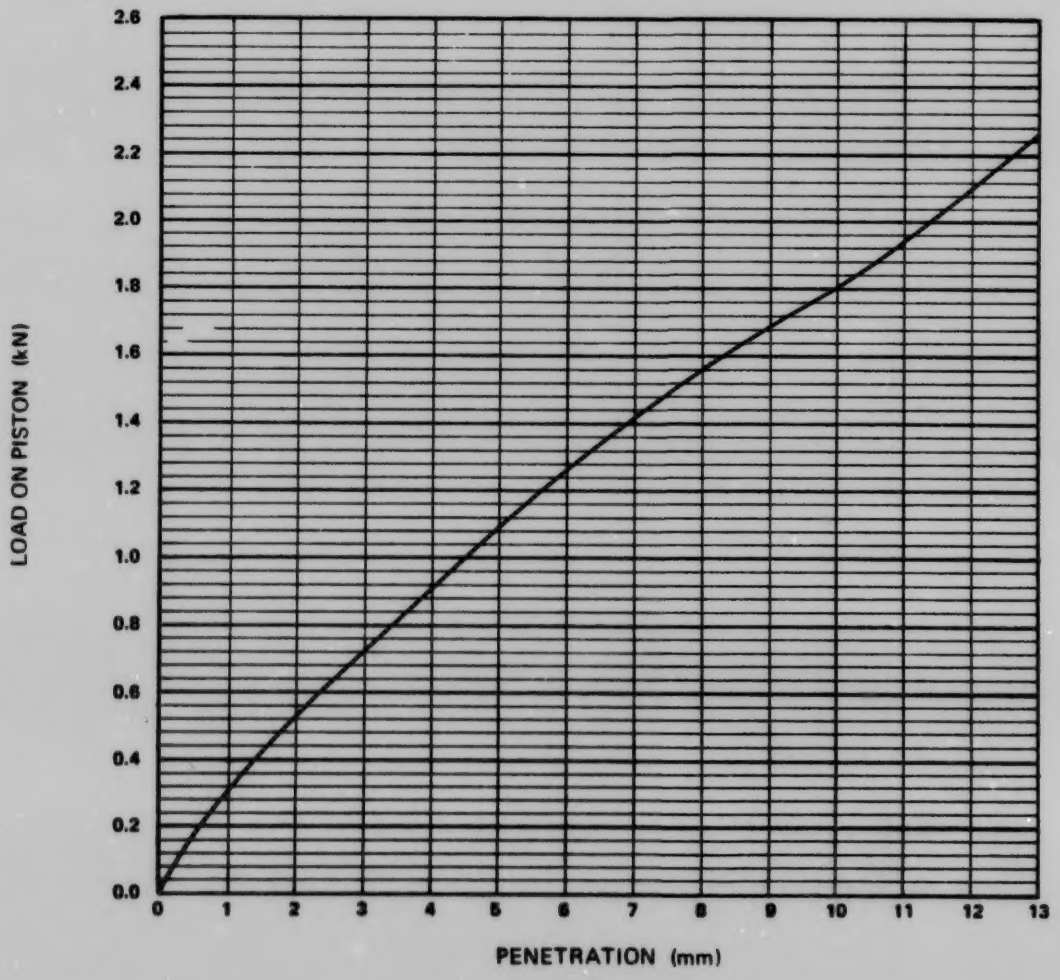
CEMENT ______ %

Final Moisture Content: 21.2 %

California Bearing Ratio: 2.5 mm 4.6 %

5.0 mm 5.4 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 75% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Pincher Creek

Sand 16%, Silt 46%, Clay 38%

Initial Dry Density: 1458 kg/m^3

Initial Moisture Content: 27.8 %

Stabilizer Dosage: FUJIBETON ____ %

FLYASH 7 %

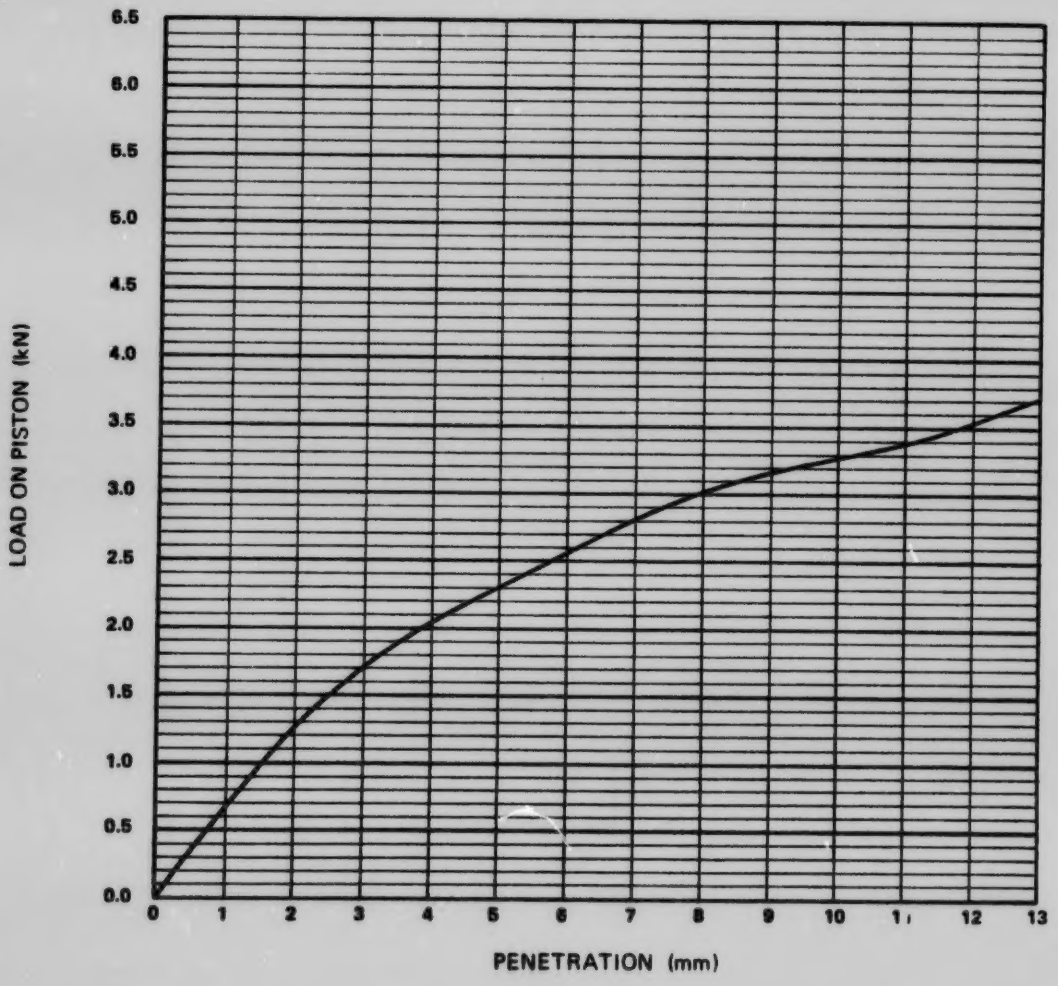
CEMENT 3 %

Final Moisture Content: 30.3 %

California Bearing Ratio: 2.5 mm 11 %

5.0 mm 12 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 100% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Pincher Creek

Sand 16% , Silt 46% , Clay 38%

Initial Dry Density: 1412.8 kg/m^3

Initial Moisture Content: 23.8 %

Stabilizer Dosage: FUJIBETON ____ %

Final Moisture Content: 28.9 %

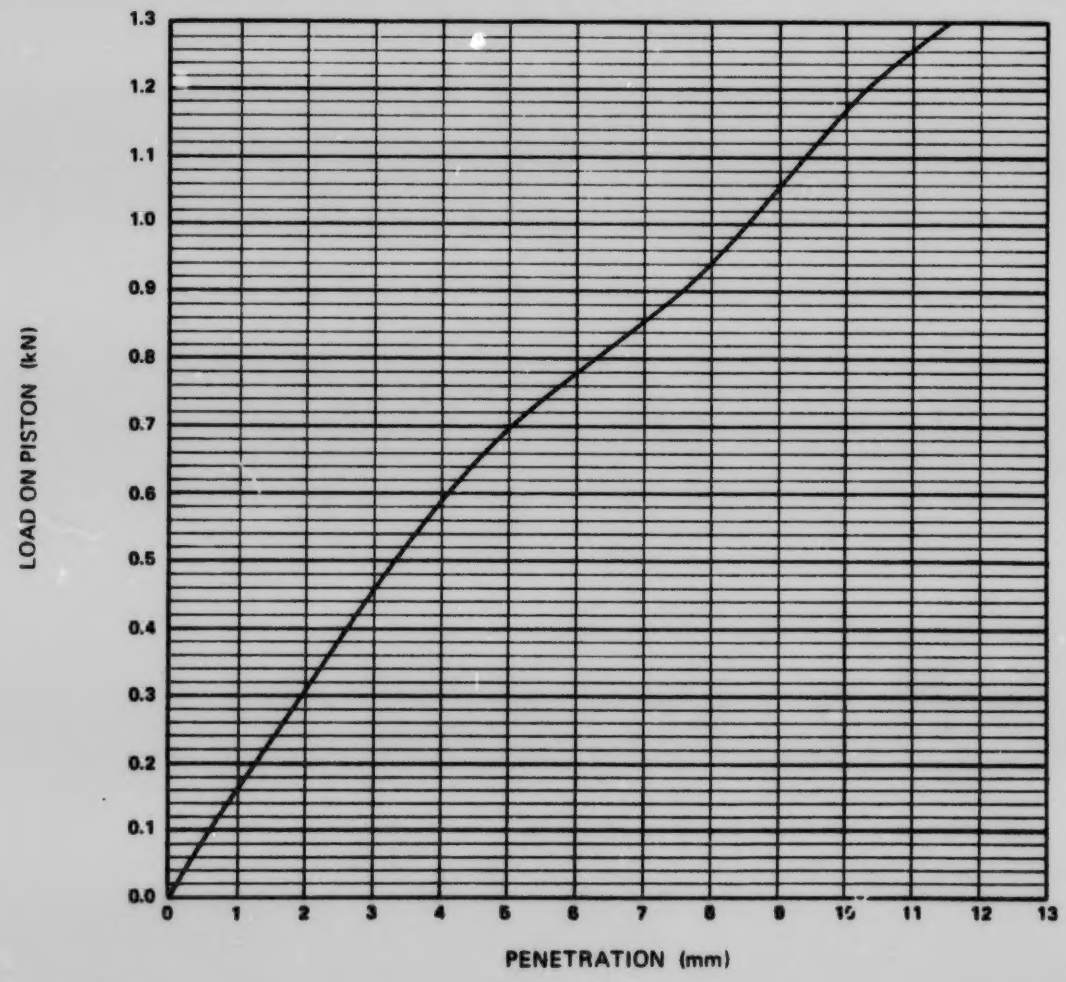
FLYASH 7 %

California Bearing Ratio: 2.5 mm 3.0 %

CEMENT 3 %

5.0 mm 3.5 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 75% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 · 00026

Project No.: 314 · 1264.02

Design Maximum Dry Density: 1455 kg/m3

Sample: Pincher Creek

Design Optimum Moisture Content:% 25.2 %

Sand 16 %, Silt 46 %, Clay 38 %

Initial Dry Density: 1355 kg/m3

Initial Moisture Content: 27.2 %

Initial Volume: 923.4 cm3

Stabilizer Dosage: FUJIBETON 2 %

FLYASH %

CEMENT %

Volume After Curing: 945.0 cm3

Final Moisture Content: --- %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 559 · 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm3)	VOLUME AFTER DRYING AND BRUSHING (cm3)	WEIGHT AFTER DRYING AND BRUSHING (g)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during first immersion.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1490 kg/m3

Sample: Pincher Creek

Sand 16 %, Silt 46 %, Clay 38 %

Design Optimum Moisture Content: % 24.0 %

Initial Dry Density: 1356 kg/m3

Initial Moisture Content: 33.5 %

Initial Volume: 931.4 cm3

Stabilizer Dosage: FUJIBETON 2 %

FLYASH %

CEMENT %

Volume After Curing: --- cm3

Final Moisture Content: 39.5 %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 559 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm^3)	VOLUME AFTER DRYING AND BRUSHING (cm^3)	WEIGHT AFTER DRYING AND BRUSHING (g)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during initial curing period.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client:	TRANSPORT CANADA	Contract No.:	1 SD 83 - 00026
Project No.:	314 - 1264.02	Design Maximum Dry Density:	1480 kg/m3
Sample:	Pincher Creek	Design Optimum Moisture Content:%	26.0 %
	Sand 16 %, Silt 46 %, Clay 38 %	Initial Dry Density:	1368 kg/m3
		Initial Moisture Content:	29.2 %
		Initial Volume:	918.7 cm3
Stabilizer Dosage: FUJIBETON	4 %	Volume After Curing:	938.8 cm3
FLYASH	%	Final Moisture Content:	--- %
CEMENT	%	Stabilized Soil Loss:	100 %

Method of Sample Preparation: ASTM D 559 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm3)	VOLUME AFTER DRYING AND BRUSHING (cm3)	WEIGHT AFTER DRYING AND BRUSHING (g)
1	918.1	854.4	1319.5
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during second immersion.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1435 kg/m³

Sample: Pincher Creek

Design Optimum Moisture Content:% 26.0 %

Sand 16 %, Silt 46 %, Clay 38 %

Initial Dry Density: 1434 kg/m³

Initial Moisture Content: 25.5 %

Initial Volume: 931.6 cm³

Stabilizer Dosage: FUJIBETON 4 %

Volume After Curing: --- cm³

FLYASH %

Final Moisture Content: 35.8 %

CEMENT %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 559 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm³)	VOLUME AFTER DRYING AND BRUSHING (cm³)	WEIGHT AFTER DRYING AND BRUSHING (g)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during initial curing period.

EBA Engineering Consultants Ltd.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Project No.: 314 - 1264.02

Sample: Pincher Creek

Sand 16 %, Silt 46 %, Clay 38 %

Stabilizer Dosage: FUJIBETON 7 %

FLYASH %

CEMENT %

Contract No.: 1 SD 83 - 00026

Design Maximum Dry Density: 1542 kg/m3

Design Optimum Moisture Content:% 15.2 %

Initial Dry Density: 1434 kg/m3

Initial Moisture Content: 17.4 %

Initial Volume: 933.3 cm3

Volume After Curing: 935.2 cm3

Final Moisture Content: --- %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 559 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm3)	VOLUME AFTER DRYING AND BRUSHING (cm3)	WEIGHT AFTER DRYING AND BRUSHING (g)
1	935.2		
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during first drying period.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Project No.: 314 - 1264.02

Sample: Pincher Creek

Sand 16 %, Silt 46 %, Clay 38 %

Stabilizer Dosage: FUJIBETON 7 %

FLYASH %

CEMENT %

Contract No.: 1 SD 83 - 00026

Design Maximum Dry Density: 1485 kg/m^3

Design Optimum Moisture Content:% 24.0 %

Initial Dry Density: 1437 kg/m^3

Initial Moisture Content: 18.6 %

Initial Volume: 930.6 cm^3

Volume After Curing: --- cm^3

Final Moisture Content: 37.0 %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 559 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm^3)	VOLUME AFTER DRYING AND BRUSHING (cm^3)	WEIGHT AFTER DRYING AND BRUSHING (g)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during initial curing period.

EBA Engineering Consultants Ltd.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1535 kg/m3

Sample: Pincher Creek

Design Optimum Moisture Content:% 23.0 %

Sand 16 %, Silt 46 %, Clay 38 %

Initial Dry Density: 1436 kg/m3

Initial Moisture Content: 23.9 %

Initial Volume: 946.8 cm3

Stabilizer Dosage: FUJIBETON 9 %

Volume After Curing: 957.1 cm3

FLYASH %

Final Moisture Content: --- %

CEMENT %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 559 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm3)	VOLUME AFTER DRYING AND BRUSHING (cm3)	WEIGHT AFTER DRYING AND BRUSHING (g)
1	951.8	887.1	1392.5
2	946.8	659.0	1064.6
3	669.5		
4			
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during third drying period.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client:	TRANSPORT CANADA	Contract No.:	1 SD 83 - 00026
Project No.:	314 - 1264.02	Design Maximum Dry Density:	1541 kg/m3
Sample:	Pincher Creek	Design Optimum Moisture Content:%	17.1 %
	Sand 16 %, Silt 46 %, Clay 38 %	Initial Dry Density:	1437 kg/m3
		Initial Moisture Content:	18.5 %
		Initial Volume:	940.1 cm3
Stabilizer Dosage: FUJIBETON	12 %	Volume After Curing:	941.1 cm3
FLYASH	%	Final Moisture Content:	--- %
CEMENT	%	Stabilized Soil Loss:	100 %

Method of Sample Preparation: ASTM D 559 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA

CYCLE	VOLUME AFTER SOAKING (cm3)	VOLUME AFTER DRYING AND BRUSHING (cm3)	WEIGHT AFTER DRYING AND BRUSHING (g)
1	950.1		
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during first drying period.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1450 kg/m3

Sample: Pincher Creek

Sand 16 %, Silt 46 %, Clay 38 %

Design Optimum Moisture Content:% 25.0 %

Initial Dry Density: 1419 kg/m3

Initial Moisture Content: 26.7 %

Initial Volume: 942.2 cm3

Stabilizer Dosage: FUJIBETON 9 %

Volume After Curing: 987.5 cm3

FLYASH %

Final Moisture Content: 36.6 %

CEMENT %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 559 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm3)	VOLUME AFTER DRYING AND BRUSHING (cm3)	WEIGHT AFTER DRYING AND BRUSHING (g)
1	1034.0	998.9	1669.3
2	1038.0	904.7	1634.0
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during third immersion.

EBA Engineering Consultants Ltd.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1485 kg/m3

Sample: Pincher Creek

Design Optimum Moisture Content:% 24.5 %

Sand 16 %, Silt 46 %, Clay 38 %

Initial Dry Density: 1454 kg m3

Initial Moisture Content: 21.5 %

Initial Volume: 899.5 cm3

Stabilizer Dosage FUJIBETON 12 %

Volume After Curing: 1127.0 cm3

FLYASH ______ %

Final Moisture Content: 37.8 %

CEMENT ______ %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 559 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm^3)	VOLUME AFTER DRYING AND BRUSHING (cm^3)	WEIGHT AFTER DRYING AND BRUSHING (g)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during first immersion.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Project No.: 314 - 1264.02

Sample: Pincher Creek

Sand 16 %, Silt 46 %, Clay 38 %

Contract No.: 1 SD 83 - 00026

Design Maximum Dry Density: 1500 kg/m3

Design Optimum Moisture Content:% 25.0 %

Initial Dry Density: 1419 kg/m3

Initial Moisture Content: 29.7 %

Initial Volume: 932.0 cm3

Volume After Curing: 941.0 cm3

Final Moisture Content: --- %

Stabilized Soil Loss: 16 %

Stabilizer Dosage: FUJIBETON 16 %

FLYASH %

CEMENT %

Method of Sample Preparation: ASTM D 559 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm^3)	VOLUME AFTER DRYING AND BRUSHING (cm^3)	WEIGHT AFTER DRYING AND BRUSHING (g)
1	929.1	917.2	1408.0
2	925.7	917.8	1323.6
3	927.5	915.9	1316.3
4	929.0	911.2	1324.5
5	926.8	919.3	1306.7
6	926.5	917.7	1287.7
7	927.9	920.2	1297.0
8	921.5	905.3	1261.6
9	896.8	886.7	1261.4
10	867.2	878.2	1211.9
11	802.7	778.9	1189.7
12	798.4	785.3	1173.2

Remarks: Unconfined Compressive Strength test not possible as sample disintegrated during hanlding after durability test.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1470 kg/m3

Sample: Pincher Creek

Design Optimum Moisture Content:% 29.0 %

Sand 16 %, Silt 46 %, Clay 38 %

Initial Dry Density: 1363 kg/m3

Initial Moisture Content: 28.6 %

Initial Volume: 943.6 cm3

Stabilizer Dosage: FUJIBETON 16 %

Volume After Curing: 984.6 cm3

FLYASH %

Final Moisture Content: 37.8 %

CEMENT %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 559 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm3)	VOLUME AFTER DRYING AND BRUSHING (cm3)	WEIGHT AFTER DRYING AND BRUSHING (g)
1	986.3		
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during handling after first immersion.

EBA Engineering Consultants Ltd.

eba

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1545 kg/m3

Sample: Pincher Creek

Design Optimum Moisture Content:% 24.2 %

Sand 16 %, Silt 46 %, Clay 38 %

Initial Dry Density: 1533 kg/m3

Initial Moisture Content: 18.6 %

Initial Volume: 958.6 cm3

Stabilizer Dosage: FUJIBETON ____ %

Volume After Curing: 954.2 cm3

FLYASH 2 %

Final Moisture Content: --- %

CEMENT ____ %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 559 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm3)	VOLUME AFTER DRYING AND BRUSHING (cm3)	WEIGHT AFTER DRYING AND BRUSHING (g)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during first immersion.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client:	TRANSPORT CANADA	Contract No.:	1 SD 83 - 00026
Project No.:	314 - 1264.02	Design Maximum Dry Density:	1480 kg/m3
Sample:	Pincher Creek	Design Optimum Moisture Content:%	25.0 %
	Sand 16 %, Silt 46 %, Clay 38 %	Initial Dry Density:	1418 kg/m3
		Initial Moisture Content:	29.8 %
		Initial Volume:	936.7 cm3
Stabilizer Dosage: FUJIBETON	%	Volume After Curing:	--- cm3
FLYASH	2 %	Final Moisture Content:	41.4 %
CEMENT	%	Stabilized Soil Loss:	100 %

Method of Sample Preparation: ASTM D 559 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm3)	VOLUME AFTER DRYING AND BRUSHING (cm3)	WEIGHT AFTER DRYING AND BRUSHING (g)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during initial curing period.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client:	TRANSPORT CANADA	Contract No.:	1 SD 83 - 00026
Project No.:	314 - 1264.02	Design Maximum Dry Density:	1540 kg/m³
Sample:	Pincher Creek	Design Optimum Moisture Content:%	22.5 %
	Sand 16 %, Silt 46 %, Clay 38 %	Initial Dry Density:	1495 kg/m³
		Initial Moisture Content:	19.3 %
		Initial Volume:	956.7 cm³
Stabilizer Dosage: FUJIBETON	%	Volume After Curing:	960.7 cm³
FLYASH	6 %	Final Moisture Content:	--- %
CEMENT	%	Stabilized Soil Loss:	100 %

Method of Sample Preparation: ASTM D 559 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm³)	VOLUME AFTER DRYING AND BRUSHING (cm³)	WEIGHT AFTER DRYING AND BRUSHING (g)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during first immersion.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client:	TRANSPORT CANADA	Contract No.:	1 SD 83 - 00026
Project No.:	314 - 1264.02	Design Maximum Dry Density:	1500 kg/m³
Sample:	Pincher Creek	Design Optimum Moisture Content:%	24.0 %
	Sand 16 %, Silt 46 %, Clay 38 %	Initial Dry Density:	1421 kg/m³
		Initial Moisture Content:	28.6 %
		Initial Volume:	928.8 cm³
Stabilizer Dosage: FUJIBETON	%	Volume After Curing:	--- cm³
FLYASH	6 %	Final Moisture Content:	37.0 %
CEMENT	%	Stabilized Soil Loss:	100 %

Method of Sample Preparation: ASTM D 559 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm³)	VOLUME AFTER DRYING AND BRUSHING (cm³)	WEIGHT AFTER DRYING AND BRUSHING (g)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during initial curing period.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1537 kg/m3

Sample: Pincher Creek

Sand 16 %, Silt 46 %, Clay 38 %

Design Optimum Moisture Content:% 22.5 %

Initial Dry Density: 1411 kg/m3

Initial Moisture Content: 26.3 %

Initial Volume: 931.4 cm3

Stabilizer Dosage: FUJIBETON ____ %

FLYASH 10 %

CEMENT ____ %

Volume After Curing: 968.0 cm3

Final Moisture Content: --- %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 559 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm3)	VOLUME AFTER DRYING AND BRUSHING (cm3)	WEIGHT AFTER DRYING AND BRUSHING (g)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during first immersion.

EBA Engineering Consultants Ltd.

eba

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Project No.: 314 · 1264.02

Sample: Pincher Creek

Sand 16 %, Silt 46 %, Clay 38 %

Stabilizer Dosage: FUJIBETON ______ %

FLYASH 10 %

CEMENT ______ %

Contract No.: 1 SD 83 · 00026

Design Maximum Dry Density: 1460 kg/m^3

Design Optimum Moisture Content:% 23.0 %

Initial Dry Density: 1412 kg/m^3

Initial Moisture Content: 28.2 %

Initial Volume: 934.9 cm^3

Volume After Curing: --- cm^3

Final Moisture Content: 36.9 %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 559 · 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm^3)	VOLUME AFTER DRYING AND BRUSHING (cm^3)	WEIGHT AFTER DRYING AND BRUSHING (g)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during initial curing period.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 · 00026

Project No.: 314 · 1264.02

Design Maximum Dry Density: 1600 kg/m3

Sample: Pincher Creek

Sand 16 %, Silt 46 %, Clay 38 %

Design Optimum Moisture Content:% 18.6 %

Initial Dry Density: 1465 kg/m3

Initial Moisture Content: 22.5 %

Initial Volume: 950.4 cm3

Volume After Curing: 1115.0 cm3

Final Moisture Content: --- %

Stabilized Soil Loss: 100 %

Stabilizer Dosage:

FUJIBETON ____ %

FLYASH 13 %

CEMENT ____ %

Method of Sample Preparation: ASTM D 559 · 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm3)	VOLUME AFTER DRYING AND BRUSHING (cm3)	WEIGHT AFTER DRYING AND BRUSHING (g)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during first immersion.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1500 kg/m³

Sample: Pincher Creek

Design Optimum Moisture Content:% 18.0 %

Sand 16 %, Silt 46 %, Clay 38 %

Initial Dry Density: 1436 kg/m³

Initial Moisture Content: 24.3 %

Initial Volume: 927.3 cm³

Stabilizer Dosage: FUJIBETON ______ %

Volume After Curing: --- cm³

FLYASH 13 %

Final Moisture Content: 36.9 %

CEMENT ______ %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 559 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm³)	VOLUME AFTER DRYING AND BRUSHING (cm³)	WEIGHT AFTER DRYING AND BRUSHING (g)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during initial curing period.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 · 00026

Project No.: 314 · 1264.02

Design Maximum Dry Density: 1735 kg/m³

Sample: Pincher Creek

Design Optimum Moisture Content: % 16.0 %

Sand 16 %, Silt 46 %, Clay 38 %

Initial Dry Density: 1662 kg m³

Initial Moisture Content: 14.3 %

Initial Volume: 949.3 cm³

Stabilizer Dosage FUJIBETON %

Volume After Curing: 978.2 cm³

FLYASH 16 %

Final Moisture Content: --- %

CEMENT %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 559 · 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm³)	VOLUME AFTER DRYING AND BRUSHING (cm³)	WEIGHT AFTER DRYING AND BRUSHING (g)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during first immersion.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA	Contract No.: 1 SD 83 - 00026
Project No.: 314 - 1264.02	Design Maximum Dry Density: 1480 kg/m³
Sample: Pincher Creek	Design Optimum Moisture Content:% 19.0 %
Sand 16 %, Silt 46 %, Clay 38 %	Initial Dry Density: 1455 kg/m³
	Initial Moisture Content: 21.8 %
	Initial Volume: 939.0 cm³
Stabilizer Dosage FUJIBETON %	Volume After Curing: --- cm³
FLYASH 16 %	Final Moisture Content: 36.2 %
CEMENT %	Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 559 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm³)	VOLUME AFTER DRYING AND BRUSHING (cm³)	WEIGHT AFTER DRYING AND BRUSHING (g)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during initial curing period.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1538 kg/m3

Sample: Pincher Creek

Design Optimum Moisture Content:%: 21.1 %

Sand 16 %, Silt 46 %, Clay 38 %

Initial Dry Density: 1471 kg/m3

Initial Moisture Content: 19.5 %

Initial Volume: 915.0 cm3

Stabilizer Dosage: FUJIBETON ______ %

Volume After Curing: 949.7 cm3

FLYASH 7 %

Final Moisture Content: 39.9 %

CEMENT 3 %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 559 - 57 but sample statically compacted to approximately 95% of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm3)	VOLUME AFTER DRYING AND BRUSHING (cm3)	WEIGHT AFTER DRYING AND BRUSHING (g)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during first immersion.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1400 kg/m3

Sample: Pincher Creek

Design Optimum Moisture Content:% 25.0 %

Sand 16 %, Silt 46 %, Clay 38 %

Initial Dry Density: 1277 kg/m3

Initial Moisture Content: 27.5 %

Initial Volume: 939.8 cm3

Stabilizer Dosage: FUJIBETON ____ %

Volume After Curing: 1009.7 cm3

FLYASH 7 %

Final Moisture Content: --- %

CEMENT 3 %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 559 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm3)	VOLUME AFTER DRYING AND BRUSHING (cm3)	WEIGHT AFTER DRYING AND BRUSHING (g)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during first immersion.

EBA Engineering Consultants Ltd.

eba

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1455 kg/m³

Sample: Pincher Creek

Sand 16 %, Silt 46 %, Clay 38 %

Design Optimum Moisture Content: 25.2 %

Initial Dry Density: 1360 kg/m³

Initial Moisture Content: 26.6 %

Initial Volume: 925.6 cm³

Stabilizer Dosage: FUJIBETON 2 %

FLYASH %

CEMENT %

Volume After Curing: --- cm³

Final Moisture Content: --- %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 560 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm³)	WEIGHT AFTER THAWING AND BRUSHING (g)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated during fifth thawing period

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Project No.: 314 - 1264.02

Sample: Pincher Creek

Sand 16 %, Silt 46 %, Clay 38 %

Stabilizer Dosage: FUJIBETON 2 %

FLYASH %

CEMENT %

Contract No.: 1 SD 83 - 00026

Design Maximum Dry Density: 1490 kg/m^3

Design Optimum Moisture Content: 24.0 %

Initial Dry Density: 1381 kg/m^3

Initial Moisture Content: 30.2 %

Initial Volume: 953.3 cm^3

Volume After Curing: --- cm^3

Final Moisture Content: 39.7 %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 560 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm^3)	WEIGHT AFTER THAWING AND BRUSHING (g)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated during initial curing period

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1480 kg/m^3

Sample: Pincher Creek

Sand 16 %, Silt 46 %, Clay 38 %

Design Optimum Moisture Content: 26.0 %

Initial Dry Density: 1381 kg/m^3

Initial Moisture Content: 27.7 %

Initial Volume: 944.7 cm^3

Stabilizer Dosage: FUJIBETON 4 %

FLYASH %

CEMENT %

Volume After Curing: --- cm^3

Final Moisture Content: 27.8 %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 560 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm^3)	WEIGHT AFTER THAWING AND BRUSHING (g)
1	945.6	1661.9
2	944.6	1603.3
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated during handling after second thawing period

EBA Engineering Consultants Ltd.

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1435 kg/m3

Sample: Pincher Creek
Sand 16 %, Silt 46 %, Clay 38 %

Design Optimum Moisture Content: 26.0 %

Initial Dry Density: 1364 kg/m3

Initial Moisture Content: 31.4 %

Initial Volume: 952.1 cm3

Stabilizer Dosage: FUJIBETON 4 %
FLYASH %
CEMENT %

Volume After Curing: --- cm3

Final Moisture Content: 36.8 %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 560 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm3)	WEIGHT AFTER THAWING AND BRUSHING (g)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated during initial curing period

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Project No.: 314 · 1264.02

Sample: Pincher Creek

Sand 16 %, Silt 46 %, Clay 38 %

Stabilizer Dosage: FUJIBETON 7 %

FLYASH %

CEMENT %

Contract No.: 1 SD 83 · 00026

Design Maximum Dry Density: 1542 kg/m^3

Design Optimum Moisture Content: 15.2 %

Initial Dry Density: 1443 kg/m^3

Initial Moisture Content: 16.8 %

Initial Volume: 940.2 cm^3

Volume After Curing: --- cm^3

Final Moisture Content: 31.8 %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 560 · 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm^3)	WEIGHT AFTER THAWING AND BRUSHING (g)
1	954.4	1593.3
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated during handling after first thawing period

EBA Engineering Consultants Ltd.

eba

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1485 kg/m3

Sample: Pincher Creek

Design Optimum Moisture Content: 24.0 %

Sand 16 %, Silt 46 %, Clay 38 %

Initial Dry Density: 1412 kg/m3

Initial Moisture Content: 19.1 %

Initial Volume: 944.6 cm3

Stabilizer Dosage: FUJIBETON 7 %

Volume After Curing: --- cm3

FLYASH %

Final Moisture Content: 40.1 %

CEMENT %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 560 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm3)	WEIGHT AFTER THAWING AND BRUSHING (g)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated during initial curing period

EBA Engineering Consultants Ltd.

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1535 kg/m^3

Sample: Pincher Creek

Sand 16 %, Silt 46 %, Clay 38 %

Design Optimum Moisture Content: 23.0 %

Initial Dry Density: 1419 kg/m^3

Initial Moisture Content: 26.0 %

Initial Volume: 956.2 cm^3

Stabilizer Dosage: FUJIBETON 9 %

FLYASH %

CEMENT %

Volume After Curing: --- cm^3

Final Moisture Content: 27.8 %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 560 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm^3)	WEIGHT AFTER THAWING AND BRUSHING (g)
1	950.6	1676.9
2	964.9	1706.0
3	900.8	1550.6
4	872.7	1460.0
5	645.2	1216.4
6	661.6	1095.4
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated during handling after sixth thawing period

EBA Engineering Consultants Ltd.

eba

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1450 kg/m3

Sample: Pincher Creek

Sand 16 %, Silt 46 %, Clay 38 %

Design Optimum Moisture Content: 25.0 %

Initial Dry Density: 1404 kg/m3

Initial Moisture Content: 26.1 %

Initial Volume: 935.0 cm3

Stabilizer Dosage: FUJIBETON 9 %

Volume After Curing: --- cm3

FLYASH %

Final Moisture Content: 32.4 %

CEMENT %

Stabilized Soil Loss: 48 %

Method of Sample Preparation: ASTM D 560 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm3)	WEIGHT AFTER THAWING AND BRUSHING (g)
1	987.5	1795.3
2	995.4	1750.9
3	896.9	1744.0
4	990.3	1719.5
5	932.4	1690.7
6	827.7	1681.0
7	939.2	1554.9
8	914.2	1542.8
9	802.3	1401.9
10	628.0	1201.8
11	564.8	1118.9
12	596.2	931.4

Remarks: Unconfined compressive strength after durability test determined as 0.54 MPa

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1541 kg/m3

Sample: Pincher Creek

Sand 16 %, Silt 46 %, Clay 38 %

Design Optimum Moisture Content: 17.1 %

Initial Dry Density: 1440 kg/m3

Initial Moisture Content: 18.8 %

Initial Volume: 940.0 cm3

Stabilizer Dosage: FUJIBETON 12 %

FLYASH %

CEMENT %

Volume After Curing: --- cm3

Final Moisture Content: 20 %

Stabilized Soil Loss: 54 %

Method of Sample Preparation: ASTM D 560 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm^3)	WEIGHT AFTER THAWING AND BRUSHING (g)
1	933.0	1609.6
2	943.0	1663.1
3	953.6	1596.8
4	801.6	1429.2
5	694.8	1276.0
6	692.8	1156.9
7	564.0	999.6
8	539.8	882.2
9	478.4	814.2
10	486.5	809.6
11	491.6	800.1
12	450.3	769.9

Remarks: Unconfined compressive strength after durability test determined as 0.22 MPa

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1485 kg/m3

Sample: Pincher Creek

Design Optimum Moisture Content: 24.5 %

Sand 16 %, Silt 46 %, Clay 38 %

Initial Dry Density: 1460 kg/m3

Initial Moisture Content: 19.3 %

Initial Volume: 971.4 cm3

Stabilizer Dosage: FUJIBETON 12 %

Volume After Curing: --- cm3

FLYASH %

Final Moisture Content: 33.8 %

CEMENT %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 560 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm3)	WEIGHT AFTER THAWING AND BRUSHING (g)
1	1114.6	1847.6
2	898.4	1768.6
3	833.9	1618.8
4	798.1	1543.2
5		
6		
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated during fifth thawing period

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Project No.: 314 - 1264.02

Sample: Pincher Creek

Sand 16 %, Silt 46 %, Clay 38 %

Stabilizer Dosage: FUJIBETON 16 %

FLYASH %

CEMENT %

Contract No.: 1 SD 83 - 00026

Design Maximum Dry Density: 1500 kg/m³

Design Optimum Moisture Content: 25.0 %

Initial Dry Density: 1438 kg/m³

Initial Moisture Content: 23.3 %

Initial Volume: 945.9 cm³

Volume After Curing: --- cm³

Final Moisture Content: 19.8 %

Stabilized Soil Loss: 20 %

Method of Sample Preparation: ASTM D 560 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm³)	WEIGHT AFTER THAWING AND BRUSHING (g)
1	929.0	1670.2
2	934.7	1706.6
3	934.0	1724.8
4	941.9	1722.5
5	942.5	1715.0
6	950.8	1684.7
7	939.4	1667.8
8	890.4	1466.1
9	885.5	1399.8
10	934.1	1391.4
11	893.9	1362.4
12	872.9	1359.9

Remarks: Unconfined compressive strength after durability test determined as 0.89 MPa

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1470 kg/m³

Sample: Pincher Creek

Design Optimum Moisture Content: 29.0 %

Sand 16 %, Silt 46 %, Clay 38 %

Initial Dry Density: 1419 kg/m³

Initial Moisture Content: 29.7 %

Initial Volume: 941.9 cm³

Stabilizer Dosage: FUJIBETON 16 %

Volume After Curing: --- cm³

FLYASH %

Final Moisture Content: 20.7 %

CEMENT %

Stabilized Soil Loss: 12 %

Method of Sample Preparation: ASTM D 560 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm³)	WEIGHT AFTER THAWING AND BRUSHING (g)
1	960.0	1737.0
2	976.6	1714.9
3	970.1	1711.9
4	947.6	1689.7
5	932.9	1664.2
6	925.1	1641.6
7	921.6	1632.7
8	937.2	1616.8
9	900.4	1646.8
10	897.4	1594.2
11	892.5	1561.2
12	895.5	1477.6

Remarks: Unconfined compressive strength after durability test determined as 0.92 MPa

EBA Engineering Consultants Ltd.

eba

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Project No.: 314 · 1264.02

Sample: Pincher Creek

Sand 16 %, Silt 46 %, Clay 38 %

Stabilizer Dosage: FUJIBETON ____ %

FLYASH 2 %

CEMENT ____ %

Contract No.: 1 SD 83 · 00026

Design Maximum Dry Density: 1545 kg/m^3

Design Optimum Moisture Content: 24.2 %

Initial Dry Density: 1532 kg/m^3

Initial Moisture Content: 18.5 %

Initial Volume: 947.2 cm^3

Volume After Curing: --- cm^3

Final Moisture Content: 32.5 %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 560 · 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm^3)	WEIGHT AFTER THAWING AND BRUSHING (g)
1	930.1	1710.4
2	1076.8	1828.2
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated during handling after second thawing period

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1480 kg/m³

Sample: Pincher Creek

Sand 16 %, Silt 46 %, Clay 38 %

Design Optimum Moisture Content: 25.0 %

Initial Dry Density: 1408 kg/m³

Initial Moisture Content: 31.1 %

Initial Volume: 943.4 cm³

Stabilizer Dosage: FUJIBETON ______ %

FLYASH 2 %

CEMENT ______ %

Volume After Curing: --- cm³

Final Moisture Content: 39.7 %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 560 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm^3)	WEIGHT AFTER THAWING AND BRUSHING (g)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated during initial curing period

EBA Engineering Consultants Ltd.

eba

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1540 kg/m3

Sample: Pincher Creek

Sand 16 %, Silt 46 %, Clay 38 %

Design Optimum Moisture Content: 22.5 %

Initial Dry Density: 1507 kg/m3

Initial Moisture Content: 18.2 %

Initial Volume: 941.0 cm3

Stabilizer Dosage: FUJIBETON ______ %

FLYASH 6 %

CEMENT ______ %

Volume After Curing: --- cm3

Final Moisture Content: 27.6 %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 560 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm3)	WEIGHT AFTER THAWING AND BRUSHING (g)
1	931.8	1687.5
2	1083.4	1778.4
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated during handling after second thawing period

EBA Engineering Consultants Ltd.

eba

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1500 kg/m3

Sample: Pincher Creek

Design Optimum Moisture Content: 24.0 %

Sand 16 %, Silt 46 %, Clay 38 %

Initial Dry Density: 1425 kg/m3

Initial Moisture Content: 29.3 %

Initial Volume: 943.1 cm3

Stabilizer Dosage: FUJIBETON ______ %

Volume After Curing: --- cm3

FLYASH 6 %

Final Moisture Content: 34.8 %

CEMENT ______ %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 560 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm3)	WEIGHT AFTER THAWING AND BRUSHING (g)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated during initial curing period

EBA Engineering Consultants Ltd.

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1537 kg/m^3

Sample: Pincher Creek

Sand 16 %, Silt 46 %, Clay 38 %

Design Optimum Moisture Content: 22.5 %

Initial Dry Density: 1417 kg/m^3

Initial Moisture Content: 25.7 %

Initial Volume: 942.6 cm^3

Stabilizer Dosage: FUJIBETON ______ %

FLYASH 10 %

CEMENT ______ %

Volume After Curing: --- cm^3

Final Moisture Content: 25.9 %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 560 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm^3)	WEIGHT AFTER THAWING AND BRUSHING (g)
1	942.5	1681.2
2	1053.4	1698.8
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated during handling after second thawing period

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1460 kg/m^3

Sample: Pincher Creek

Design Optimum Moisture Content: 23.0 %

Sand 16 %, Silt 46 %, Clay 38 %

Initial Dry Density: 1410 kg/m^3

Initial Moisture Content: 29.1 %

Initial Volume: 934.6 cm^3

Stabilizer Dosage: FUJIBETON ___ %

Volume After Curing: --- cm^3

FLYASH 10 %

Final Moisture Content: 41.1 %

CEMENT ___ %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 560 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm^3)	WEIGHT AFTER THAWING AND BRUSHING (g)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated during initial curing period

EBA Engineering Consultants Ltd.

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Project No.: 314 - 1264.02

Sample: Pincher Creek

Sand 16 %, Silt 46 %, Clay 38 %

Stabilizer Dosage: FUJIBETON ______ %

FLYASH 13 %

CEMENT ______ %

Contract No.: 1 SD 83 - 00026

Design Maximum Dry Density: 1600 kg/m^3

Design Optimum Moisture Content: 18.6 %

Initial Dry Density: 1468 kg/m^3

Initial Moisture Content: 22.2 %

Initial Volume: 943.3 cm^3

Volume After Curing: --- cm^3

Final Moisture Content: 29.7 %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 560 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm^3)	WEIGHT AFTER THAWING AND BRUSHING (g)
1	959.7	1695.4
2	1062.1	1819.8
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated during handling after second thawing period

EBA Engineering Consultants Ltd.

eba

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1500 kg/m³

Sample: Pincher Creek

Sand 16 %, Silt 46 %, Clay 38 %

Design Optimum Moisture Content: 18.0 %

Initial Dry Density: 1450 kg/m³

Initial Moisture Content: 25.2 %

Initial Volume: 961.6 cm³

Stabilizer Dosage: FUJIBETON ____ %

FLYASH 13 %

CEMENT ____ %

Volume After Curing: --- cm³

Final Moisture Content: 35.4 %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 560 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm³)	WEIGHT AFTER THAWING AND BRUSHING (g)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated during initial curing period

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Project No.: 314 - 1264.02

Sample: Pincher Creek

Sand 16 %, Silt 46 %, Clay 38 %

Stabilizer Dosage: FUJIBETON ____ %

FLYASH 16 %

CEMENT ____ %

Contract No.: 1 SD 83 - 00026

Design Maximum Dry Density: 1735 kg/m³

Design Optimum Moisture Content: 16.0 %

Initial Dry Density: 1599 kg/m³

Initial Moisture Content: 18.7 %

Initial Volume: 952.3 cm³

Volume After Curing: --- cm³

Final Moisture Content: 27.8 %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 560 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm³)	WEIGHT AFTER THAWING AND BRUSHING (g)
1	976.8	1800.1
2	1084.7	1860.1
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated during handling after second thawing period

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1480 kg/m3

Sample: Pincher Creek

Design Optimum Moisture Content: 19.0 %

Sand 16 %, Silt 46 %, Clay 38 %

Initial Dry Density: 1421 kg/m3

Initial Moisture Content: 23.9 %

Initial Volume: 926.7 cm3

Stabilizer Dosage: FUJIBETON %

Volume After Curing: --- cm3

FLYASH 16 %

Final Moisture Content: 34.2 %

CEMENT %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 560 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm3)	WEIGHT AFTER THAWING AND BRUSHING (g)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated during initial curing period

EBA Engineering Consultants Ltd.

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1538 kg/m3

Sample: Pincher Creek

Sand 16 %, Silt 46 %, Clay 38 %

Design Optimum Moisture Content: 21.1 %

Initial Dry Density: 1461 kg/m3

Initial Moisture Content: 20.8 %

Initial Volume: 928.0 cm3

Stabilizer Dosage: FUJIBETON %

FLYASH 7 %

CEMENT 3 %

Volume After Curing: --- cm3

Final Moisture Content: --- %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 560 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm3)	WEIGHT AFTER THAWING AND BRUSHING (g)
1	931.5	1665.3
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated during second thawing period

EBA Engineering Consultants Ltd.

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1400 kg/m³

Sample: Pincher Creek

Sand 16 %, Silt 46 %, Clay 38 %

Design Optimum Moisture Content: 25.0 %

Initial Dry Density: 1278 kg/m³

Initial Moisture Content: 25.5 %

Initial Volume: 942.8 cm³

Stabilizer Dosage: FUJIBETON ____ %

FLYASH 7 %

CEMENT 3 %

Volume After Curing: --- cm³

Final Moisture Content: --- %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 560 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm³)	WEIGHT AFTER THAWING AND BRUSHING (g)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated during initial curing period

ATTERBERG LIMITS TEST DATA

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264. 02

SAMPLE	STABILIZER DOSAGE (%)			REACTION TIME (hours)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX
	FUJIBETON	FLYASH	CEMENT				
Pincher Creek II	0	0	0	–	22.6	51.5	28.9
	2	–	–	48	29.9	54.3	24.4
	2	–	–	72	36.5	61.1	24.6
	5	–	–	48	–	–	Non Plastic
	5	–	–	72	–	–	Non Plastic
	8	–	–	48	–	–	Non Plastic
	8	–	–	72	–	–	Non Plastic
	12	–	–	48	–	–	Non Plastic
	12	–	–	72	–	–	Non Plastic
	16	–	–	48	–	–	Non Plastic
	16	–	–	72	–	–	Non Plastic
	–	2	–	48	20.5	40.9	20.4
	–	2	–	72	24.1	43.5	19.5
	–	6	–	48	20.2	45.9	25.7
	–	6	–	72	25.1	46.6	21.5
	–	12	–	48	20.4	41.6	21.2
	–	12	–	72	24.1	43.8	19.7
	–	16	–	48	20.3	44.4	24.1
	–	16	–	72	26.3	42.8	16.5
	–	9	3	48	38.0	62.2	24.2
	–	9	3	72	39.9	60.2	20.3
	–	12	3	1	30.0	47.7	17.7
	–	12	3	8	27.0	52.8	25.8
	–	12	3	24	–	–	Non Plastic
	–	12	3	48	–	–	Non Plastic
	–	12	3	72	–	–	Non Plastic

ATTERBERG LIMITS TEST DATA

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

SAMPLE	STABILIZER DOSAGE (%)			REACTION TIME (hours)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX
	FUJIBETON	FLYASH	CEMENT				
Pincher Creek II	–	12	4	1	26.6	50.5	23.9
	–	12	4	8	–	–	Non Plastic
	–	12	4	24	–	–	Non Plastic
	–	12	4	48	–	–	Non Plastic
	–	12	4	72	–	–	Non Plastic
	–	12	5	1	48.7	52.8	4.1
	–	12	5	8	–	–	Non Plastic
	–	12	5	24	–	–	Non Plastic
	–	12	5	48	–	–	Non Plastic
	–	12	5	72	–	–	Non Plastic
	–	12	6	1	29.8	53.8	24.0
	–	12	6	8	–	–	Non Plastic
	–	12	6	24	–	–	Non Plastic
	–	12	6	48	–	–	Non Plastic
	–	12	6	72	–	–	Non Plastic
	–	12	7	1	31.6	56.0	24.4
	–	12	7	8	–	–	Non Plastic
	–	12	7	24	–	–	Non Plastic
	–	12	7	48	–	–	Non Plastic
	–	12	7	72	–	–	Non Plastic
	–	14	6	1	32.1	50.1	18.0
	–	14	6	8	–	–	Non Plastic
	–	14	6	24	–	–	Non Plastic
	–	14	6	48	–	–	Non Plastic
	–	14	6	72	–	–	Non Plastic
	–	14	7	1	–	–	Non Plastic
	–	14	7	8	–	–	Non Plastic

ATTERBERG LIMITS TEST DATA

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264. 02

SAMPLE	STABILIZER DOSAGE (%)			REACTION TIME (hours)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX
	FUJIBETON	FLYASH	CEMENT				
Pincher Creek II	–	14	7	24	–	–	Non Plastic
	–	14	7	48	–	–	Non Plastic
	–	14	7	72	–	–	Non Plastic
	–	16	6	1	25.7	50.5	24.8
	–	16	6	8	–	–	Non Plastic
	–	16	6	24	–	–	Non Plastic
	–	16	6	48	–	–	Non Plastic
	–	16	6	72	–	–	Non Plastic

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1SD83 - 00026

Project No.: 314 - 1264.02

Stabilizer Dosage: FUJIBETON ____ %

Sample: Pincher Creek II

FLYASH 12 %

Sand 3%, Silt 44%, Clay 53%

CEMENT 3 %

TEST DATA:

1) Method of Sample Preparation: ASTM D 558 - 57

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	13.6	1564
2	16.5	1554
3	22.4	1502
4	27.1	1437
5	8.1	1570

Design Field Optimum Moisture Content: 20 %

Design Field Maximum Dry Density: 1530 kg/m³

2) Method of Sample Preparation: ASTM D558 - 57, but using 19 blows to compact each layer instead of 25 blows

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1		
2		
3		
4		
5		

Design Field Optimum Moisture Content: ____ %

Design Field Maximum Dry Density: ____ kg/m³

SHEET 1 OF 2

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and [illegible] Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

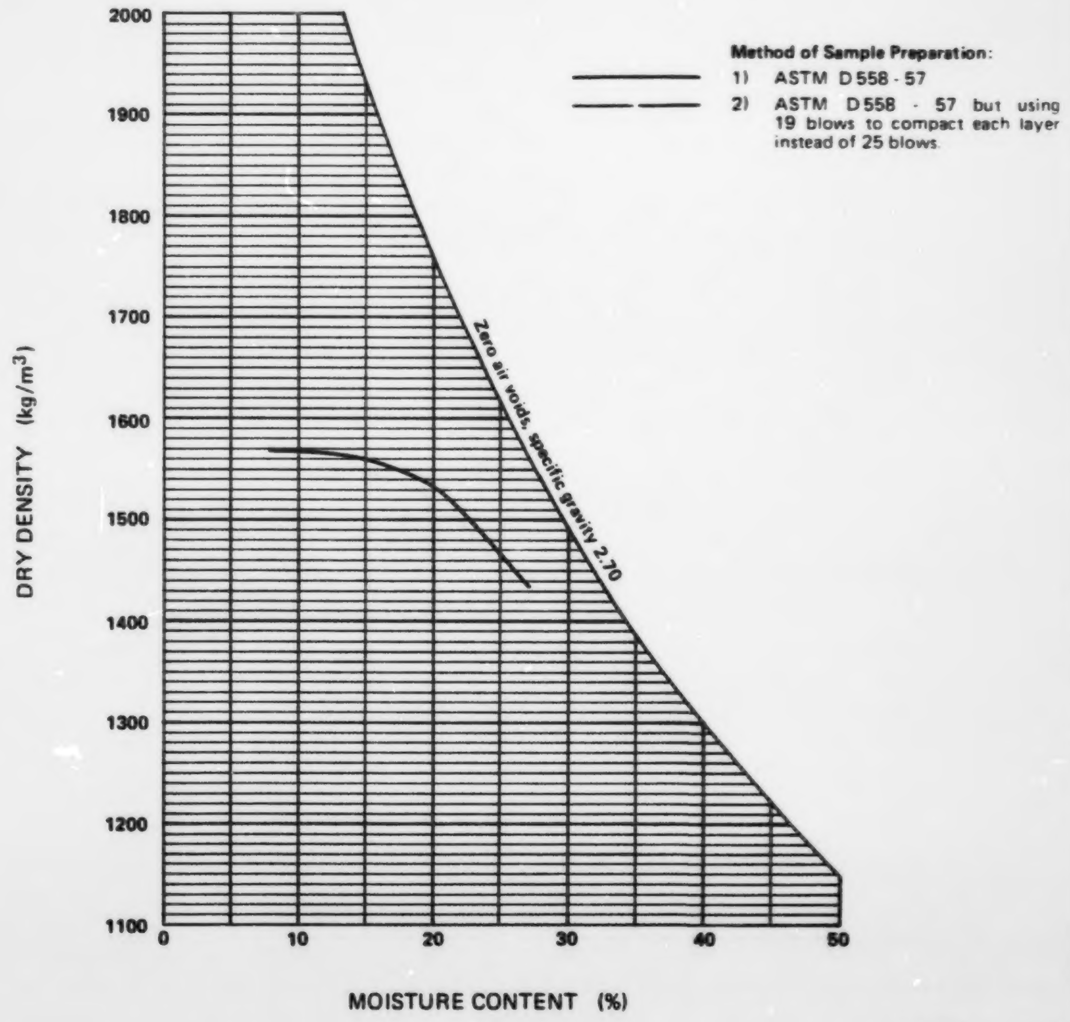
Stabilizer Dosage: FUJIBETON ____ %

Sample: Pincher Creek II

FLYASH 12 %

Sand 3 %, Silt 44 %, Clay 53 %

CEMENT 3 %



SHEET 2 OF 2

DRY DENSITY/MOISTURE CONTENT
RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1SD83 - 00026

Project No.: 314 - 1264.02

Stabilizer Dosage: FUJIBETON ____ %

Sample: Pincher Creek II

FLYASH 12 %

Sand 3%, Silt 44%, Clay 53%

CEMENT 4 %

TEST DATA:

1) Method of Sample Preparation: ASTM D 558 - 57

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	13.0	1552
2	17.3	1543
3	23.4	1499
4	26.0	1446
5	7.6	1590

Design Field Optimum Moisture Content: 20 %

Design Field Maximum Dry Density: 1525 kg/m³

2) Method of Sample Preparation: ASTM D558 - 57, but using 19 blows to compact each layer instead of 25 blows

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1		
2		
3		
4		
5		

Design Field Optimum Moisture Content: ____ %

Design Field Maximum Dry Density: ____ kg/m³

SHEET 1 OF 2

EBA Engineering Consultants Ltd.

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

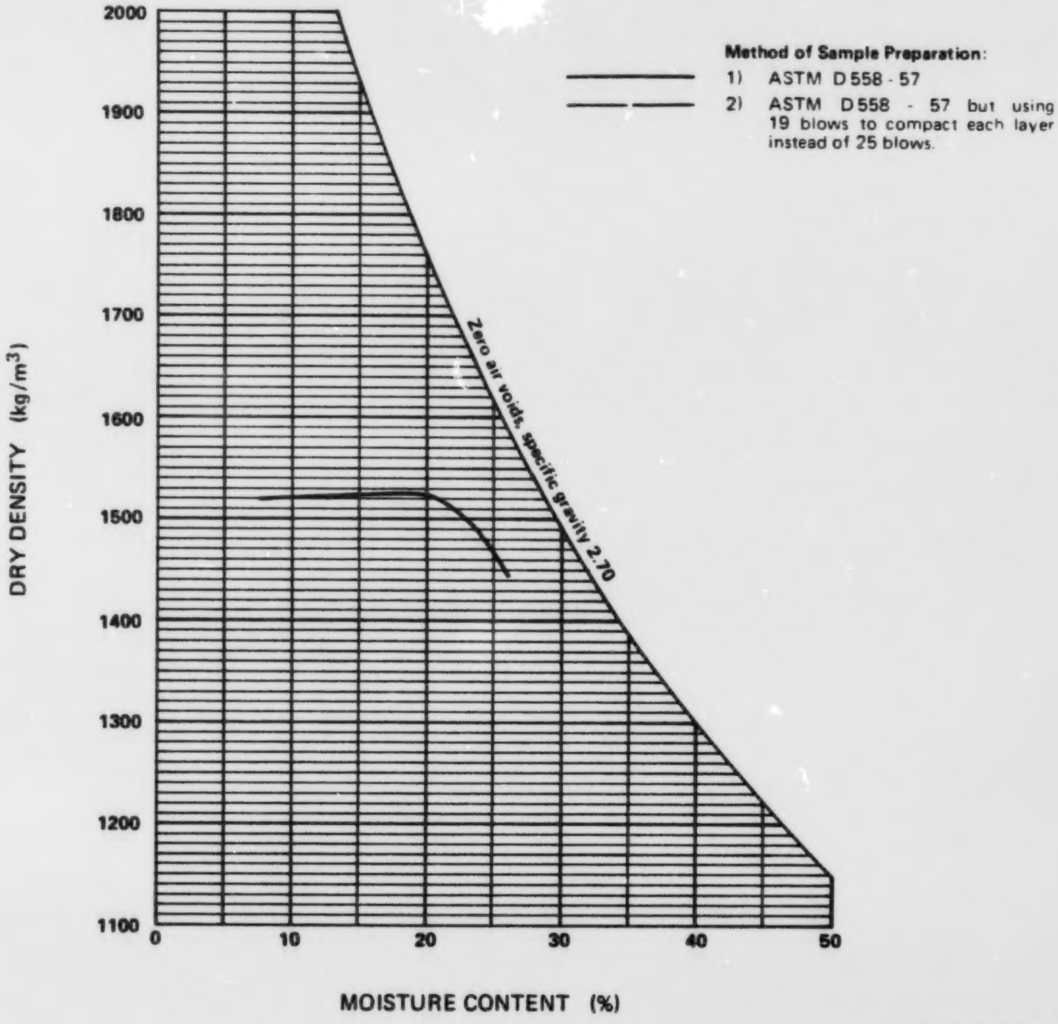
Stabilizer Dosage: FUJIBETON ____ %

Sample: Pincher Creek II

FLYASH 12 %

Sand 3 %, Silt 44 %, Clay 53 %

CEMENT 4 %



SHEET 2 OF 2

EBA Engineering Consultants Ltd.

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA Contract No.: 1SD83 - 00026

Project No.: 314 - 1264.02 Stabilizer Dosage: FUJIBETON ____ %

Sample: Pincher Creek II FLYASH 12 %

Sand 3%, Silt 44%, Clay 53% CEMENT 5 %

TEST DATA:

1) Method of Sample Preparation: ASTM D 558 - 57

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	12.6	1584
2	18.1	1530
3	21.7	1541
4	32.2	1390
5	9.2	1546

Design Field Optimum Moisture Content: 25 %

Design Field Maximum Dry Density: 1500 kg/m³

2) Method of Sample Preparation: ASTM D558 - 57, but using 19 blows to compact each layer instead of 25 blows

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1		
2		
3		
4		
5		

Design Field Optimum Moisture Content: ____ %

Design Field Maximum Dry Density: ____ kg/m³

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

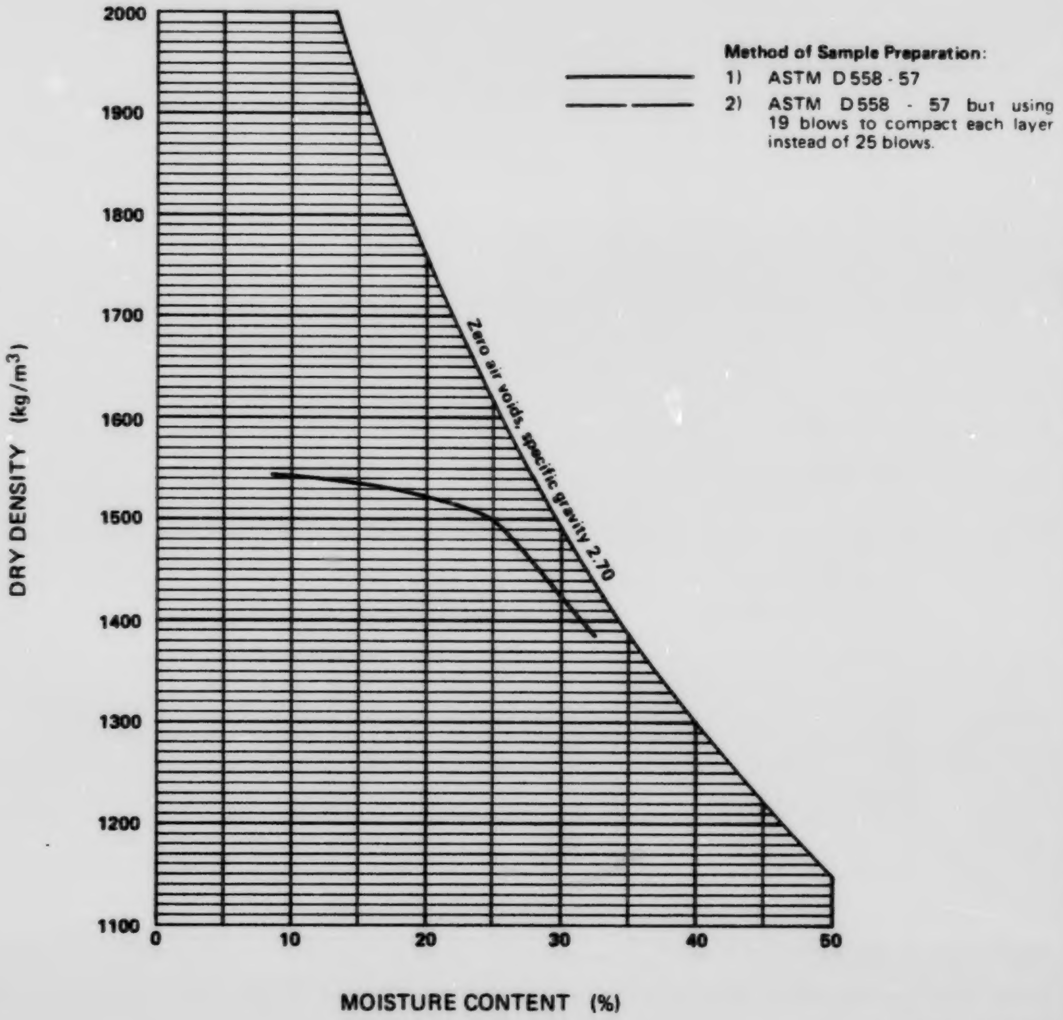
Stabilizer Dosage: FUJIBETON ____ %

FLYASH 12 %

CEMENT 5 %

Sample: Pincher Creek II

Sand 3 %, Silt 44 %, Clay 53 %



SHEET 2 OF 2

DRY DENSITY/MOISTURE CONTENT
RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1SD83 - 00026

Project No.: 314 - 1264.02

Stabilizer Dosage: FUJIBETON ____ %

FLYASH 12 %

CEMENT 6 %

Sample: Pincher Creek II

Sand 3%, Silt 44%, Clay 53%

TEST DATA:

1) Method of Sample Preparation: ASTM D 558 - 57

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m^3)
1	13.5	1560
2	17.3	1556
3	22.2	1517
4	26.5	1441
5	8.4	1567

Design Field Optimum Moisture Content: 20 %

Design Field Maximum Dry Density: 1545 kg/m^3

2) Method of Sample Preparation: ASTM D558 - 57, but using 19 blows to compact each layer instead of 25 blows

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m^3)
1		
2		
3		
4		
5		

Design Field Optimum Moisture Content: ____ %

Design Field Maximum Dry Density: ____ kg/m^3

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Pincher Creek II

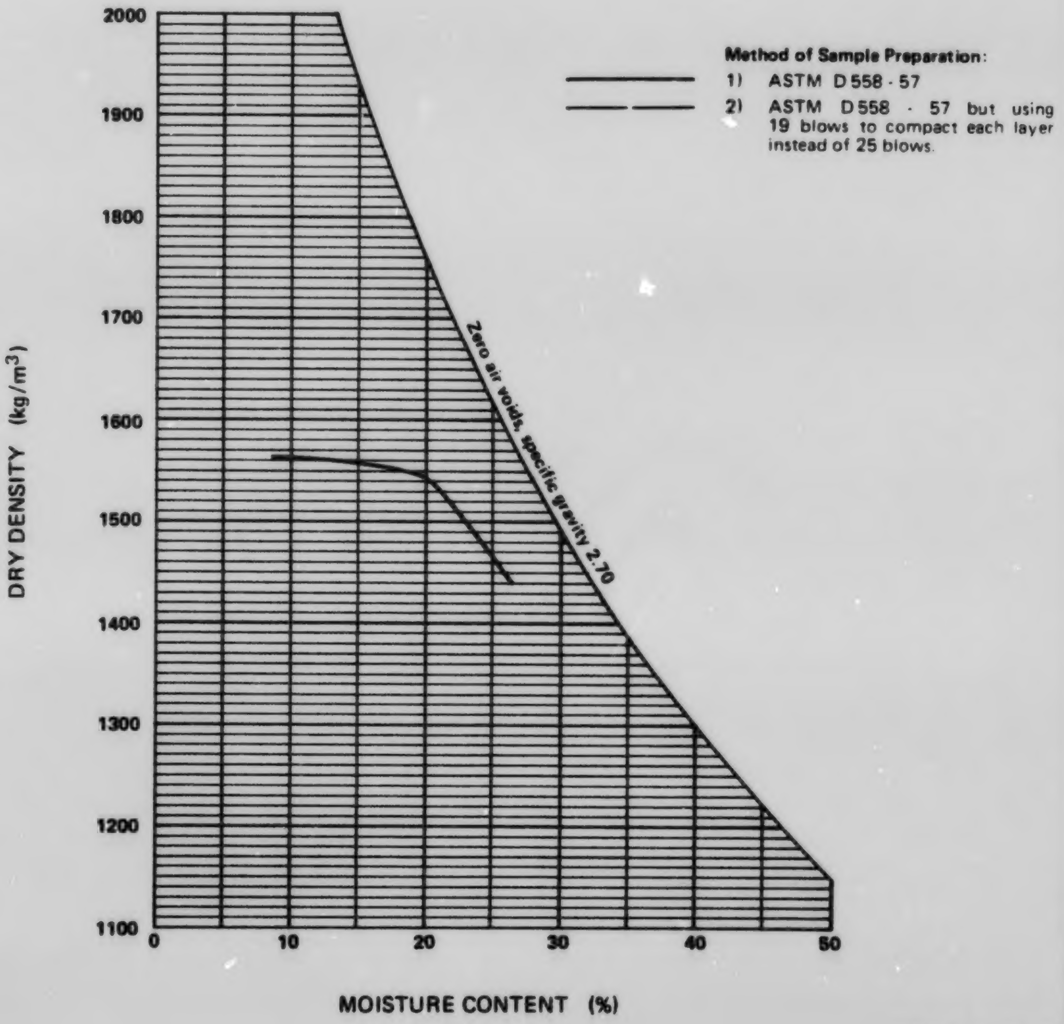
Sand 3 %, Silt 44 %, Clay 53 %

Stabilizer Dosage:

FUJIBETON ____ %

FLYASH 12 %

CEMENT 6 %



SHEET 2 OF 2

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA
Contract No.: 1SD83 - 00026

Project No.: 314 - 1264.02
Stabilizer Dosage: FUJIBETON ______ %

Sample: Pincher Creek II
FLYASH 12 %

Sand 3%, Silt 44%, Clay 53%
CEMENT 7 %

TEST DATA:

1) Method of Sample Preparation: ASTM D 558 - 57

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	14.4	1506
2	19.4	1536
3	24.4	1491
4	28.8	1433
5	10.4	1643.9

Design Field Optimum Moisture Content: 20 %

Design Field Maximum Dry Density: 1535 kg/m³

2) Method of Sample Preparation: ASTM D558 - 57, but using 19 blows to compact each layer instead of 25 blows

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1		
2		
3		
4		
5		

Design Field Optimum Moisture Content: ______ %

Design Field Maximum Dry Density: ______ kg/m³

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

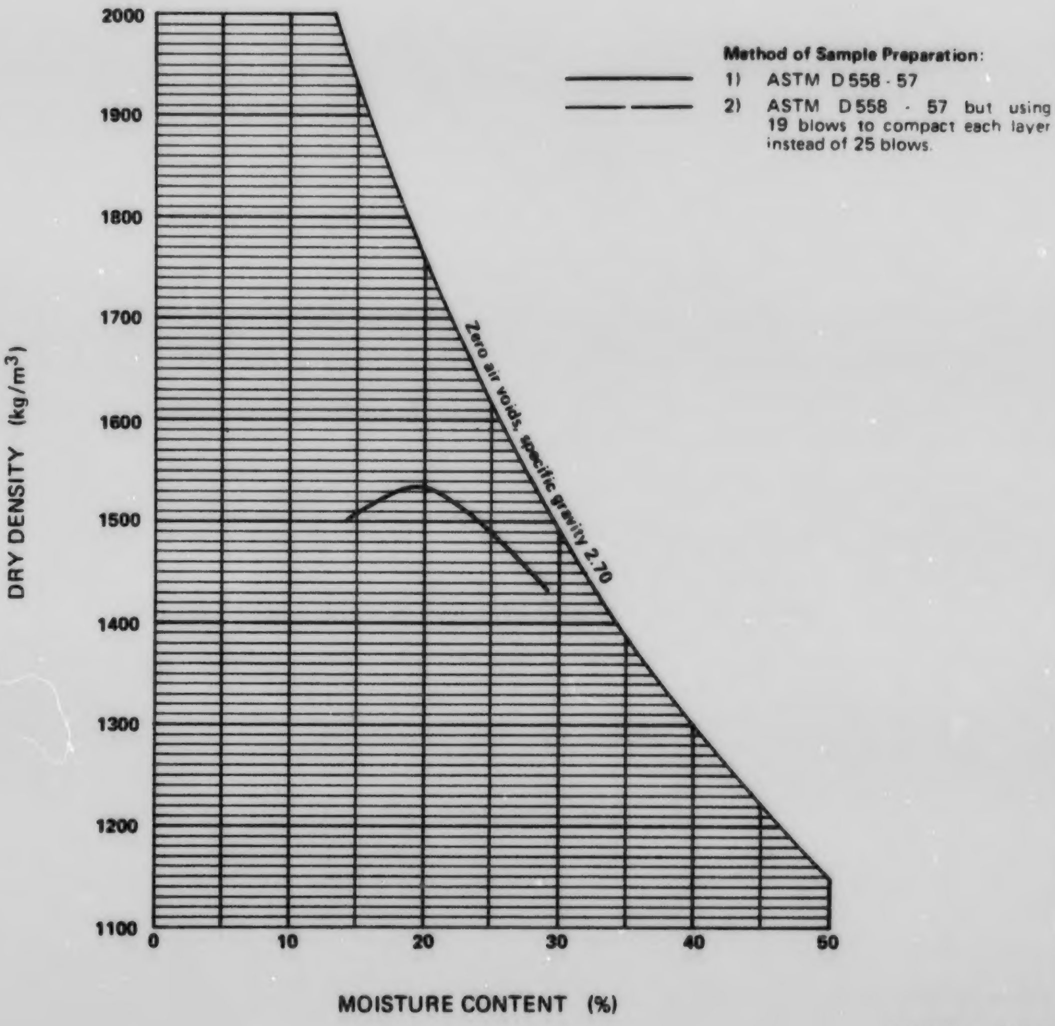
Stabilizer Dosage: FUJIBETON ____ %

FLYASH 12 %

CEMENT 7 %

Sample: Pincher Creek II

Sand 3 %, Silt 44 %, Clay 53 %



SHEET 2 OF 2

EBA Engineering Consultants Ltd.

eba

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1SD83 - 00026

Project No.: 314 - 1264.02

Stabilizer Dosage: FUJIBETON ____ %

FLYASH 14 %

CEMENT 6 %

Sample: Pincher Creek II

Sand 3%, Silt 44%, Clay 53%

TEST DATA:

1) Method of Sample Preparation: ASTM D 558 - 57

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	8.6	1570
2	12.8	1522
3	19.3	1522
4	19.3	1536
5	27.6	1436

Design Field Optimum Moisture Content: 20 %

Design Field Maximum Dry Density: 1520 kg/m³

2) Method of Sample Preparation: ASTM D558 - 57, but using 19 blows to compact each layer instead of 25 blows

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1		
2		
3		
4		
5		

Design Field Optimum Moisture Content: ____ %

Design Field Maximum Dry Density: ____ kg/m³

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

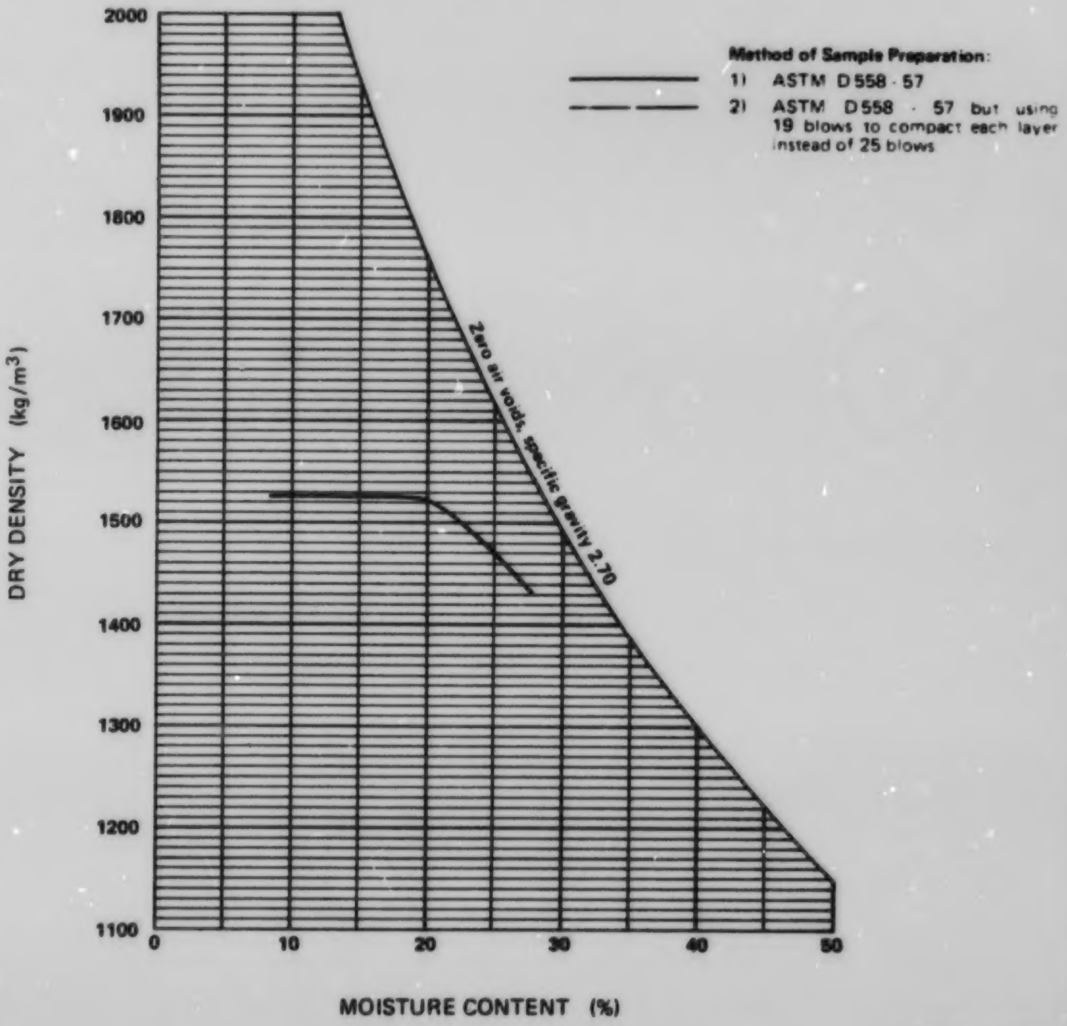
Stabilizer Dosage: FUJIBETON _____ %

FLYASH 14 %

CEMENT 6 %

Sample: Pincher Creek II

Sand 3 %, Silt 44 %, Clay 53 %



EBA Engineering Consultants Ltd.

eba

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA
Contract No.: 1SD83 - 00026

Project No.: 314 - 1264.02
Stabilizer Dosage: FUJIBETON ______ %

Sample: Pincher Creek II
FLYASH 14 %

Sand 3%, Silt 44%, Clay 53%
CEMENT 7 %

TEST DATA:

1) Method of Sample Preparation: ASTM D 558 - 57

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	14.3	1541
2	18.3	1546
3	23.3	1487
4	28.7	1413
5	10.1	1526

Design Field Optimum Moisture Content: ______ %

Design Field Maximum Dry Density: ______ kg/m³

2) Method of Sample Preparation: ASTM D558 - 57, but using 19 blows to compact each layer instead of 25 blows

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1		
2		
3		
4		
5		

Design Field Optimum Moisture Content: ______ %

Design Field Maximum Dry Density: ______ kg/m³

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

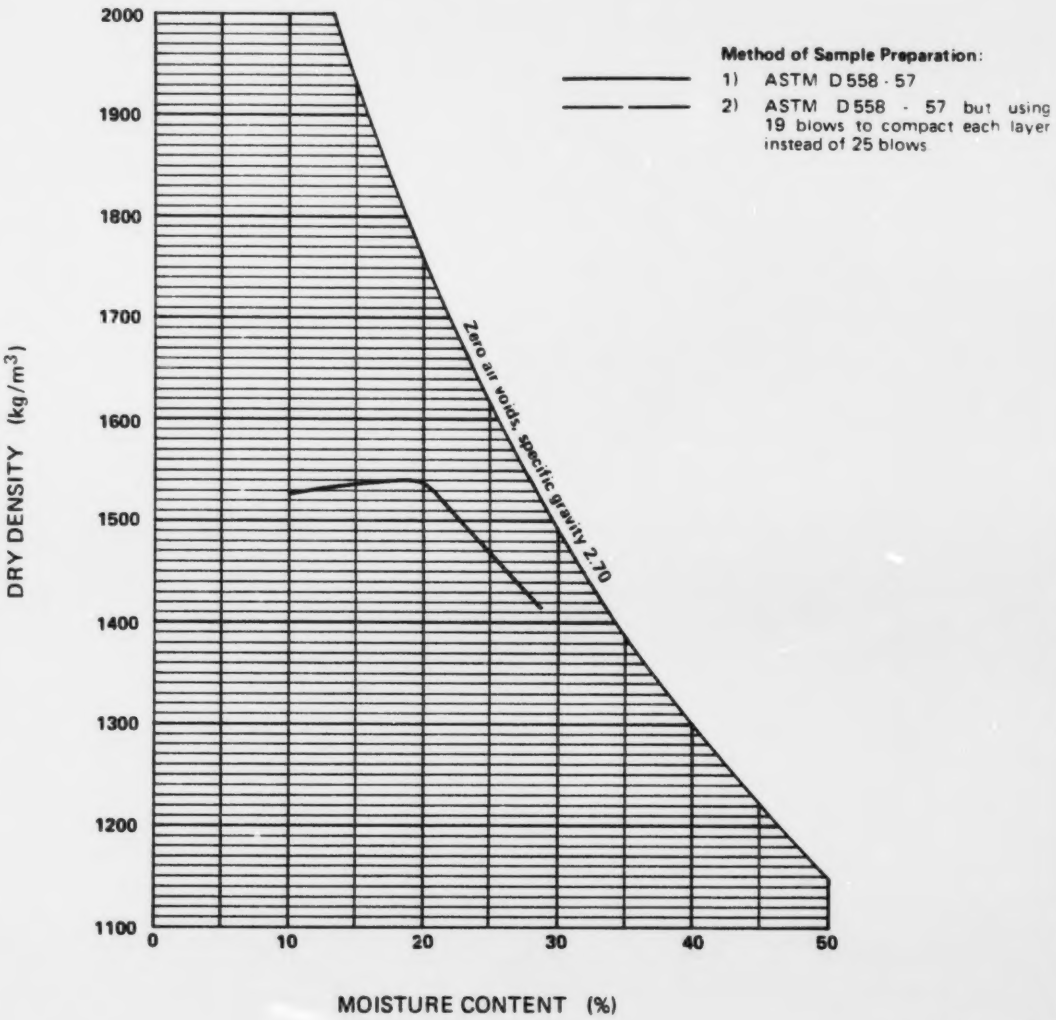
Stabilizer Dosage: FUJIBETON ______ %

FLYASH 14 %

CEMENT 7 %

Sample: Pincher Creek II

Sand 3 %, Silt 44 %, Clay 53 %



SHEET 2 OF 2

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA Contract No.: 1SD83 - 00026

Project No.: 314 - 1264.02 Stabilizer Dosage: FUJIBETON ____ %

Sample: Pincher Creek II FLYASH 16 %

Sand 3%, Silt 44%, Clay 53% CEMENT 6 %

TEST DATA:

1) Method of Sample Preparation: ASTM D 558 - 57

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	14.5	1512
2	18.0	1545
3	24.6	1507
4	28.7	1425
5	12.3	1614

Design Field Optimum Moisture Content: 20 %

Design Field Maximum Dry Density: 1555 kg/m³

2) Method of Sample Preparation: ASTM D558 - 57, but using 19 blows to compact each layer instead of 25 blows

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1		
2		
3		
4		
5		

Design Field Optimum Moisture Content: ____ %

Design Field Maximum Dry Density: ____ kg/m³

SHEET 1 OF 2

EBA Engineering Consultants Ltd.

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

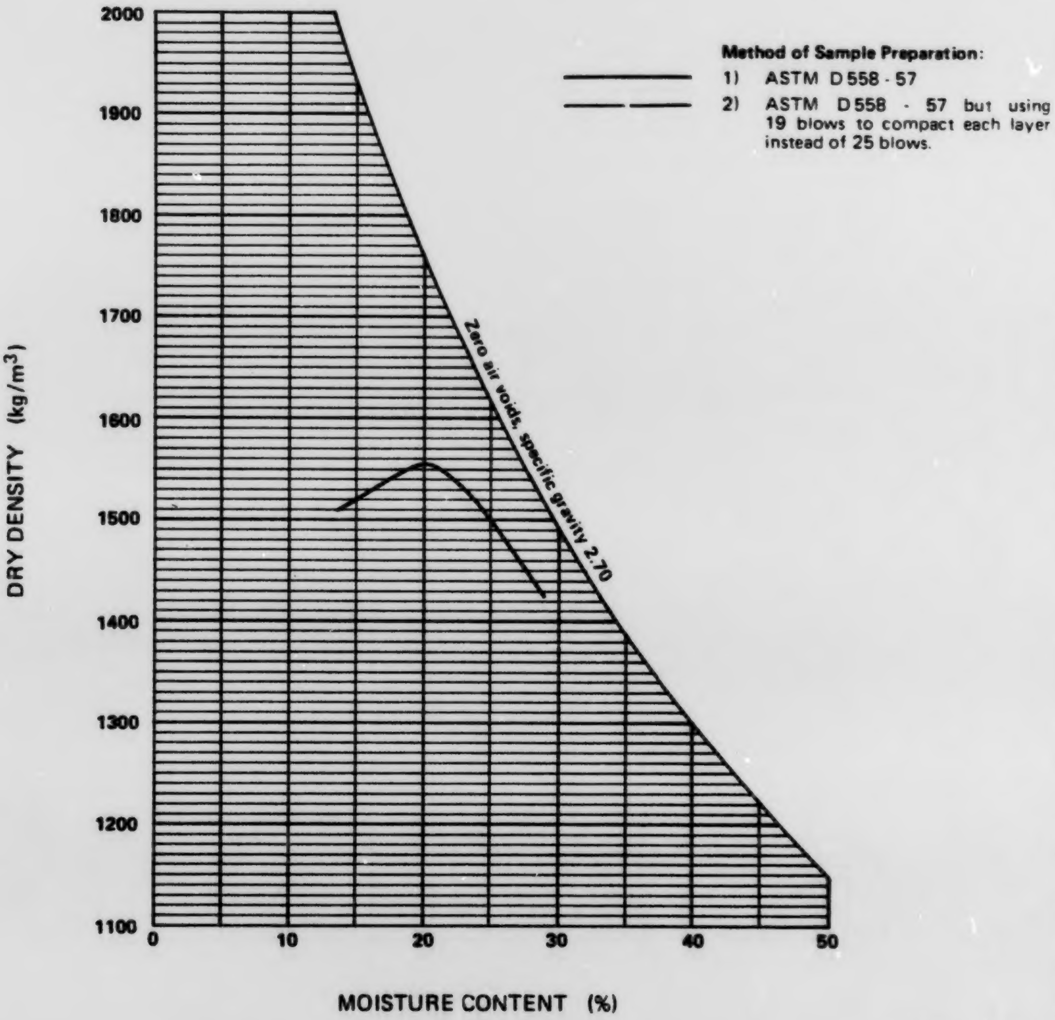
Stabilizer Dosage: FUJIBETON ______ %

Sample: Pincher Creek II

FLYASH 16 %

Sand 3 %, Silt 44 %, Clay 53 %

CEMENT 6 %



SHEET 2 OF 2

CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Pincher Creek II

Sand 3% , Silt 44% , Clay 53%

Initial Dry Density: 1420 kg/m^3

Initial Moisture Content: 22.8 %

Final Moisture Content: 40.5 %

Stabilizer Dosage: FUJIBETON ____ %

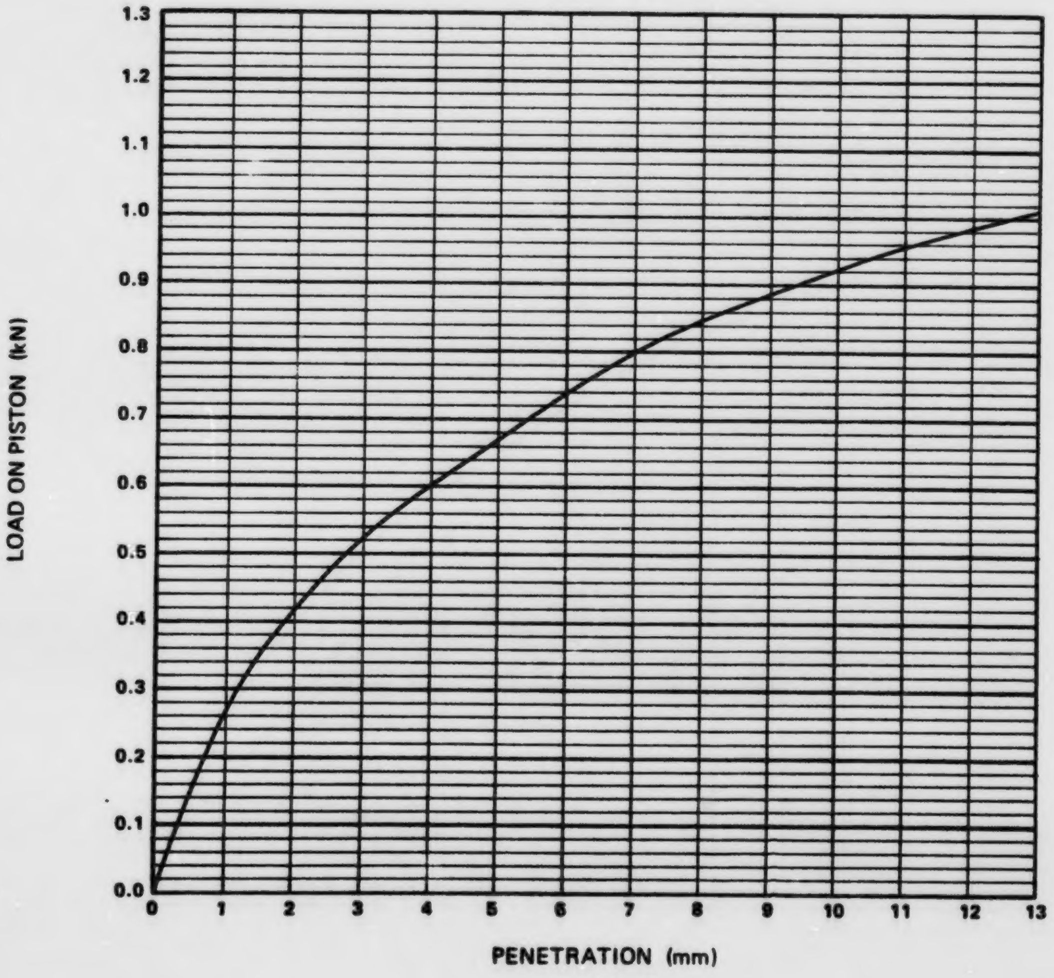
FLYASH 12 %

CEMENT 3 %

California Bearing Ratio: 2.5 mm 3.7 %

5.0 mm 3.3 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 100% of standard compactive effort, then cured at 20° C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Pincher Creek II

Sand 3%, Silt 44%, Clay 53%

Initial Dry Density: 1475 kg/m^3

Initial Moisture Content: 17.9 %

Stabilizer Dosage: FUJIBETON %

FLYASH 12 %

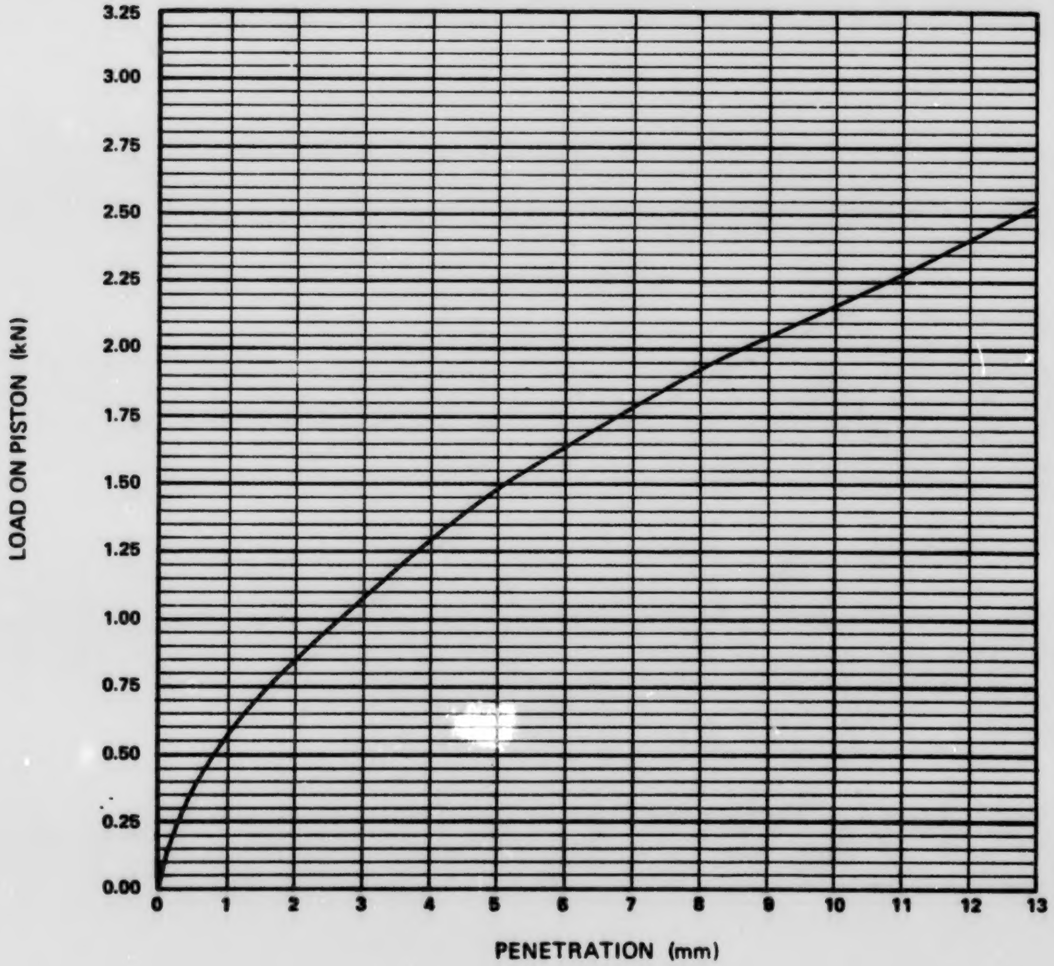
CEMENT 4 %

Final Moisture Content: 20.3 %

California Bearing Ratio: 2.5 mm 7.3 %

5.0 mm 7.5 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 100% of standard compactive effort, then cured at 20° C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA
Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Pincher Creek II
Sand 3% , Silt 44% , Clay 53%

Initial Dry Density: 1440 kg/m^3

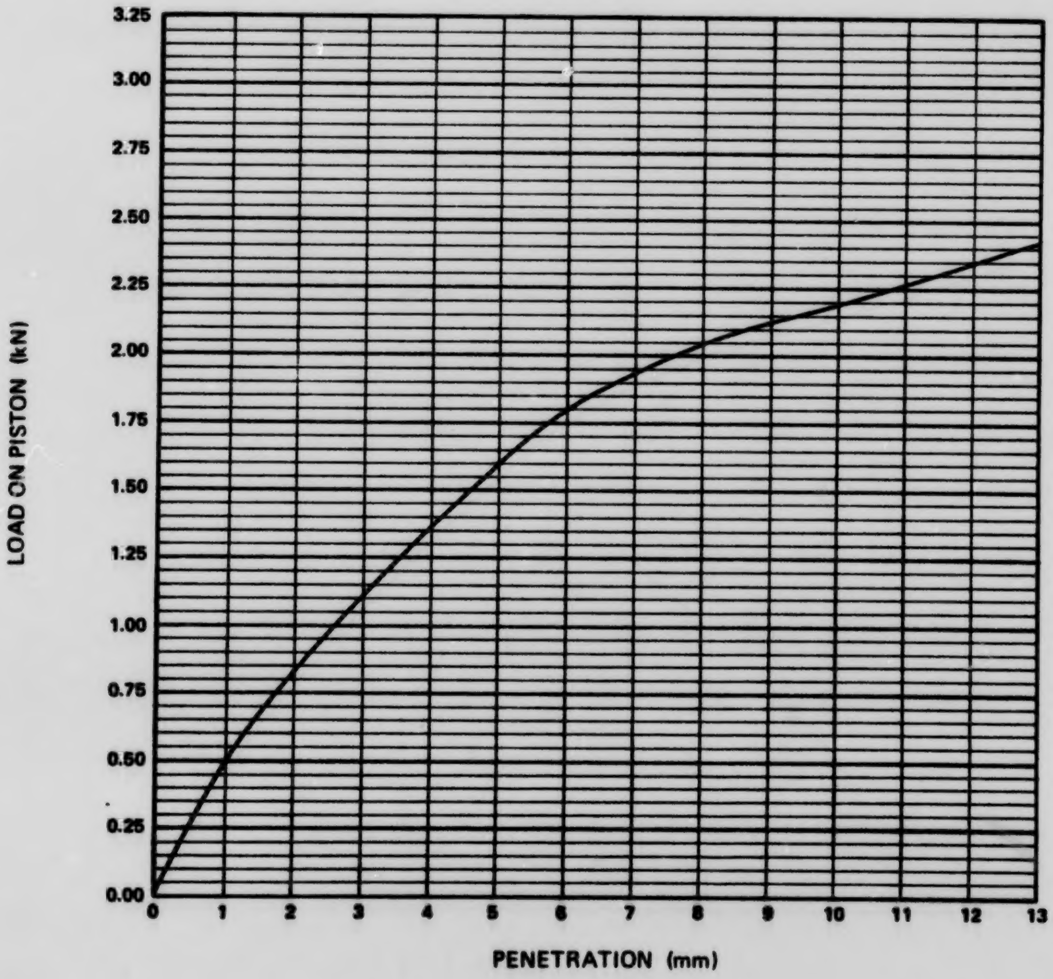
Initial Moisture Content: 23.7 %

Final Moisture Content: 29.3 %

Stabilizer Dosage: FUJIBETON ____ %
FLYASH 12 %
CEMENT 5 %

California Bearing Ratio: 2.5 mm 7.5 %
5.0 mm 8.0 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 100% of standard compactive effort, then cured at 20° C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Pincher Creek II

Sand 3% , Silt 44% , Clay 53%

Initial Dry Density: 1472 kg/m^3

Initial Moisture Content: 19.6 %

Stabilizer Dosage: FUJIBETON %

FLYASH 12 %

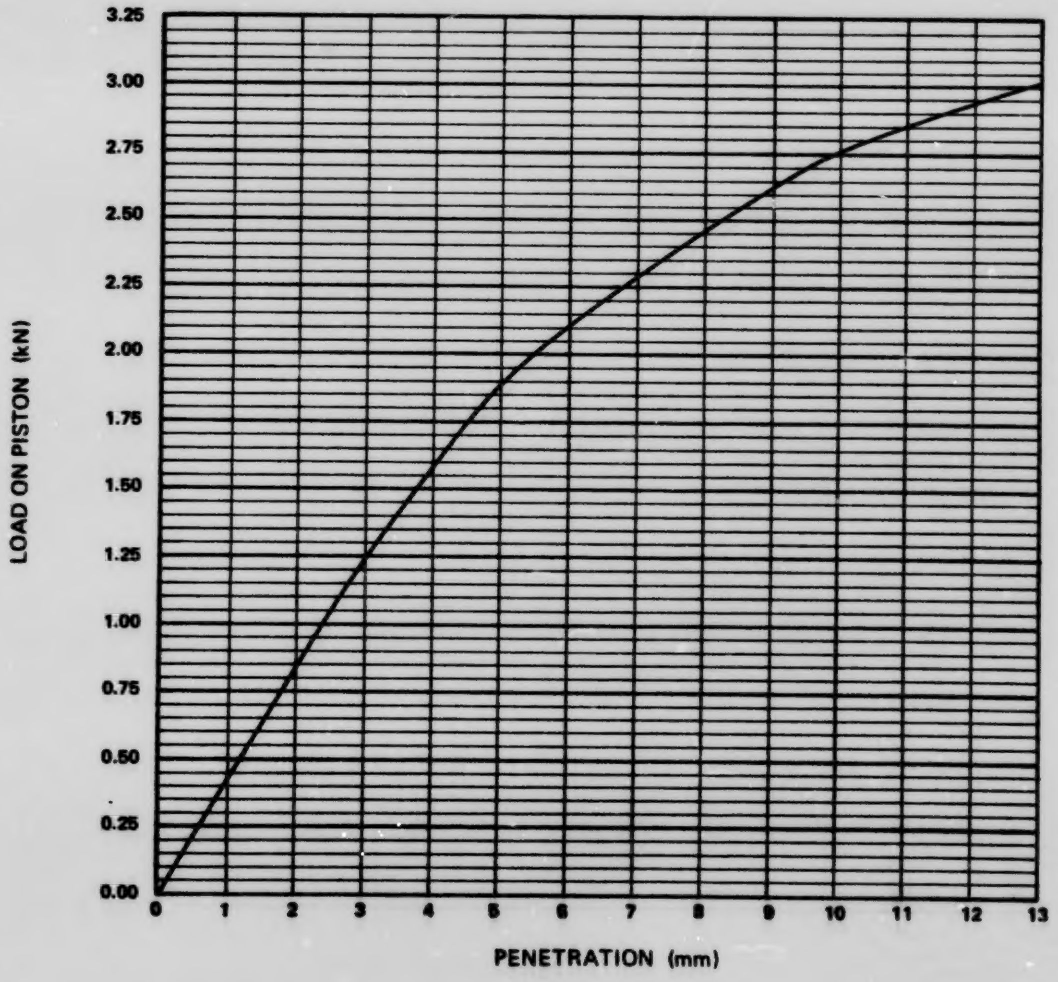
CEMENT 6 %

Final Moisture Content: 36.4 %

California Bearing Ratio: 2.5 mm 8.2 %

5.0 mm 9.5 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 100% of standard compactive effort, then cured at 20° C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Pincher Creek II

Sand 3%, Silt 44%, Clay 53%

Initial Dry Density: 1464 kg/m^3

Initial Moisture Content: 19.5 %

Final Moisture Content: 24.2 %

Stabilizer Dosage: FUJIBETON ____ %

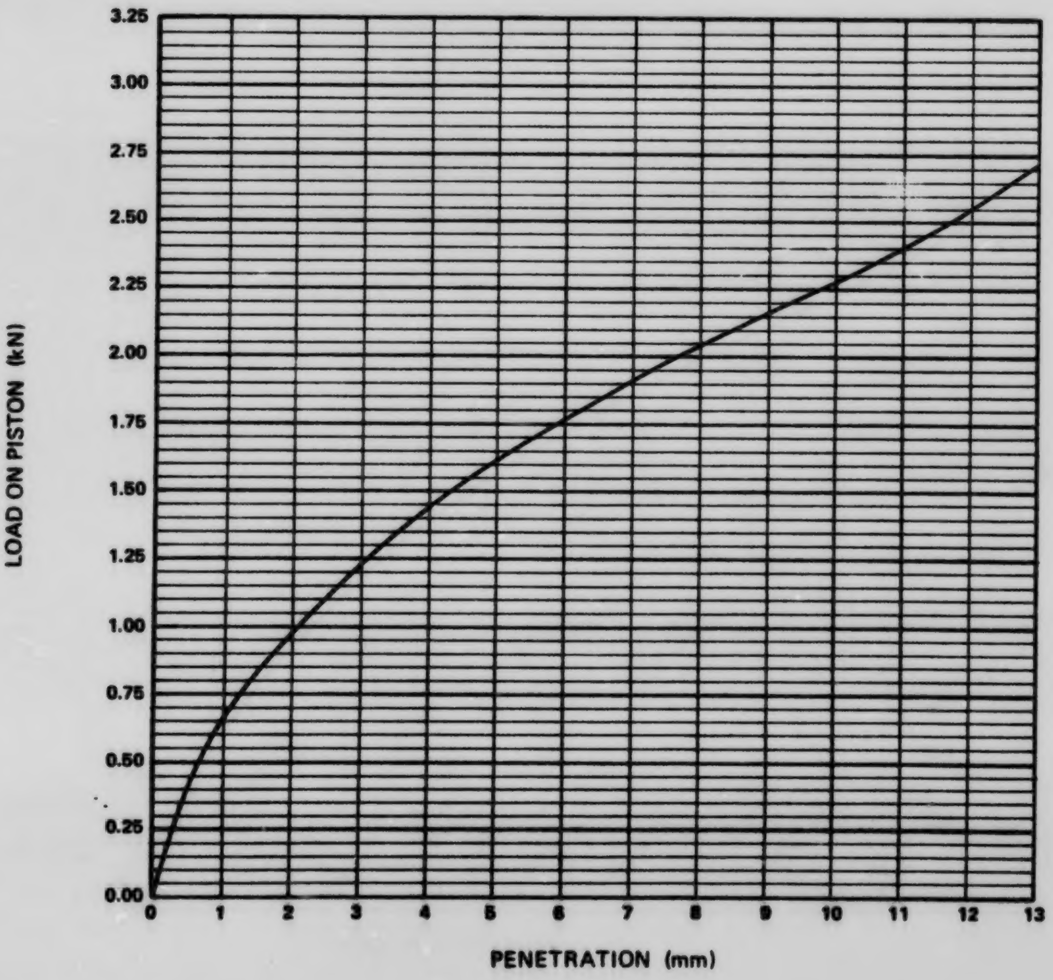
FLYASH 12 %

CEMENT 7 %

California Bearing Ratio: 2.5 mm 8.2 %

5.0 mm 8.0 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 100% of standard compactive effort, then cured at 20° C and 100% humidity for 7 days.

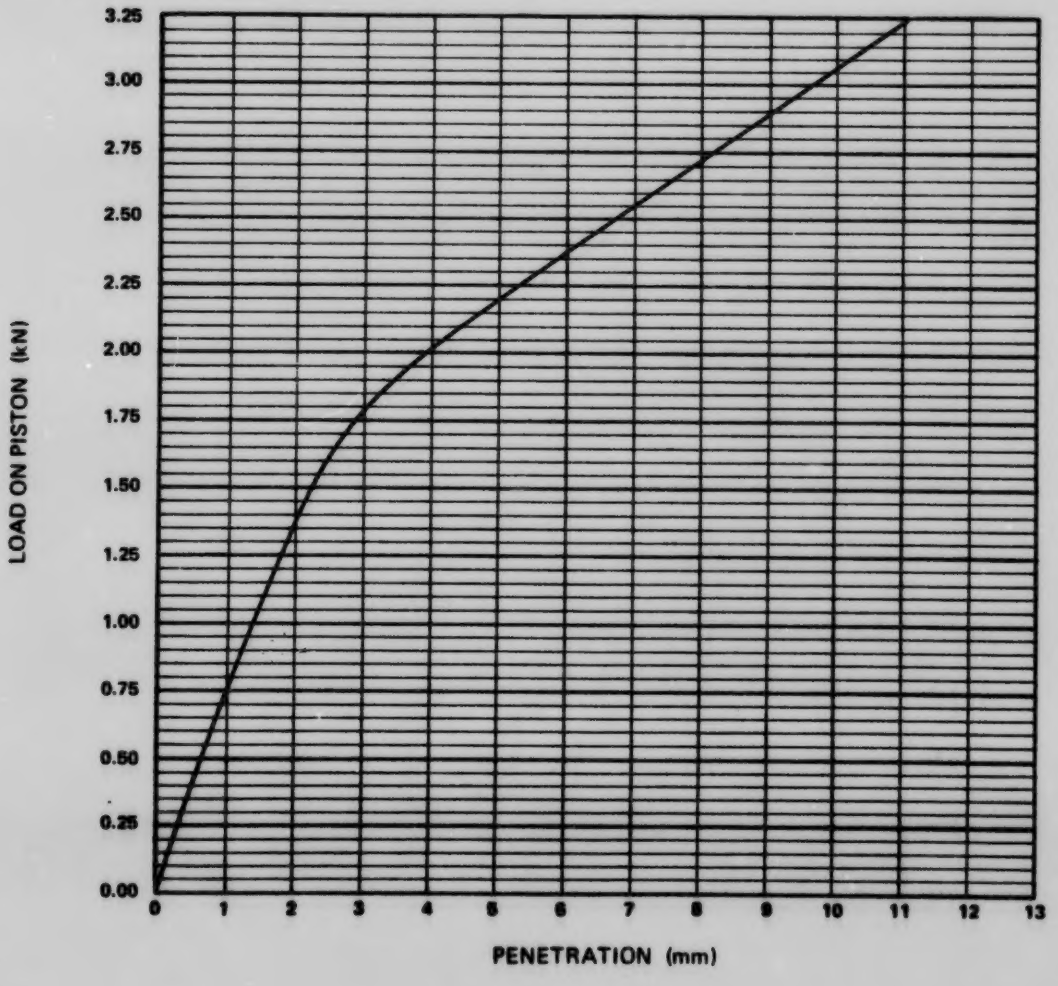


CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client:	TRANSPORT CANADA	Contract No.:	1 SD 83 - 00026
Project No.:	314 - 1264.02		
Sample:	Pincher Creek II	Initial Dry Density:	1452 kg/m^3
	Sand 3% , Silt 44% , Clay 53%	Initial Moisture Content:	19.4 %
Stabilizer Dosage: FUJIBETON	%	Final Moisture Content:	20.7 %
FLYASH	14 %	California Bearing Ratio: 2.5 mm	13 %
CEMENT	6 %	5.0 mm	11 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 100% of standard compactive effort, then cured at 20° C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA   Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Pincher Creek II   Initial Dry Density: 1486 kg/m^3

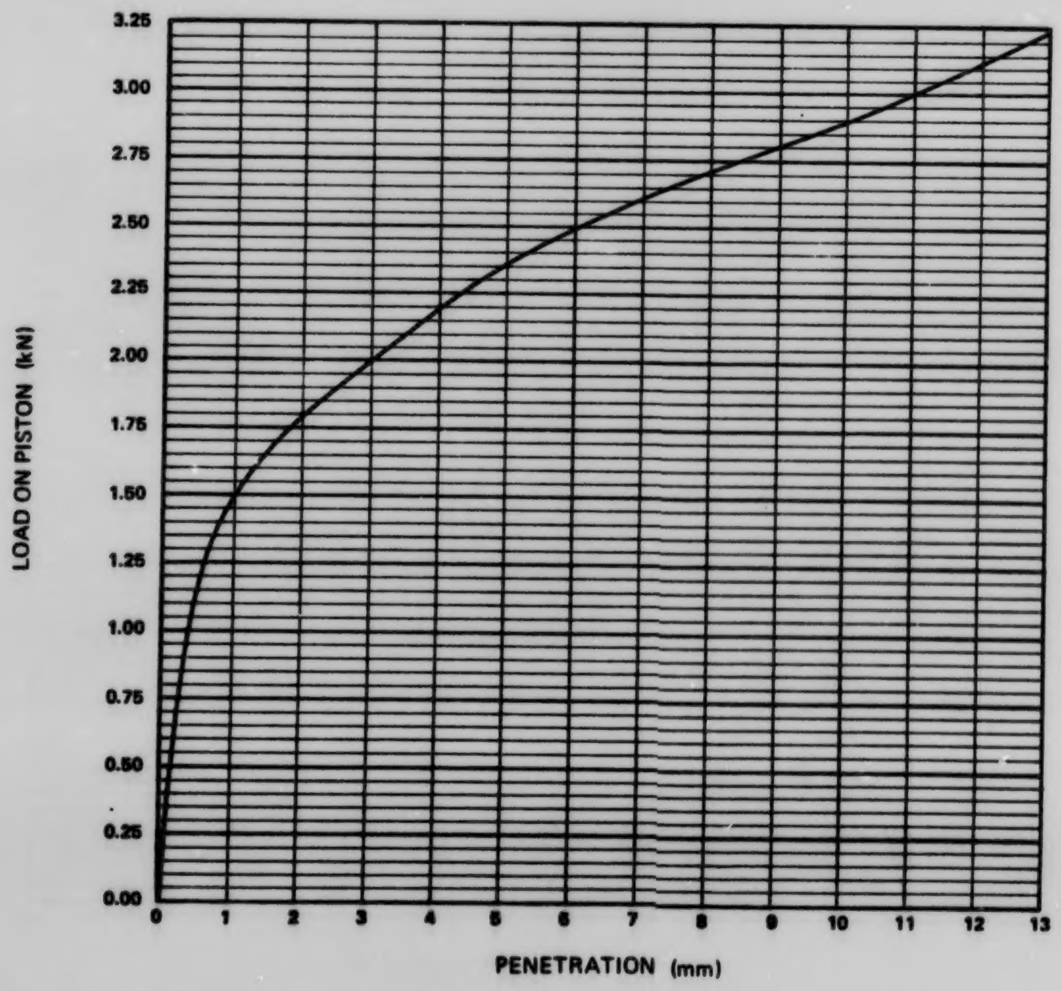
Sand 3% , Silt 44% , Clay 53%   Initial Moisture Content: 18.1 %

Stabilizer Dosage: FUJIBETON ____ %   Final Moisture Content: 29.0 %

FLYASH 14 %   California Bearing Ratio: 2.5 mm 14 %

CEMENT 7 %   5.0 mm 12 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 100% of standard compactive effort, then cured at 20° C and 100% humidity for 7 days.



EBA Engineering Consultants Ltd.

CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Pincher Creek II

Sand 3%, Silt 44%, Clay 53%

Initial Dry Density: 1479 kg/m^3

Initial Moisture Content: 19.9 %

Final Moisture Content: 21.9 %

Stabilizer Dosage: FUJIBETON %

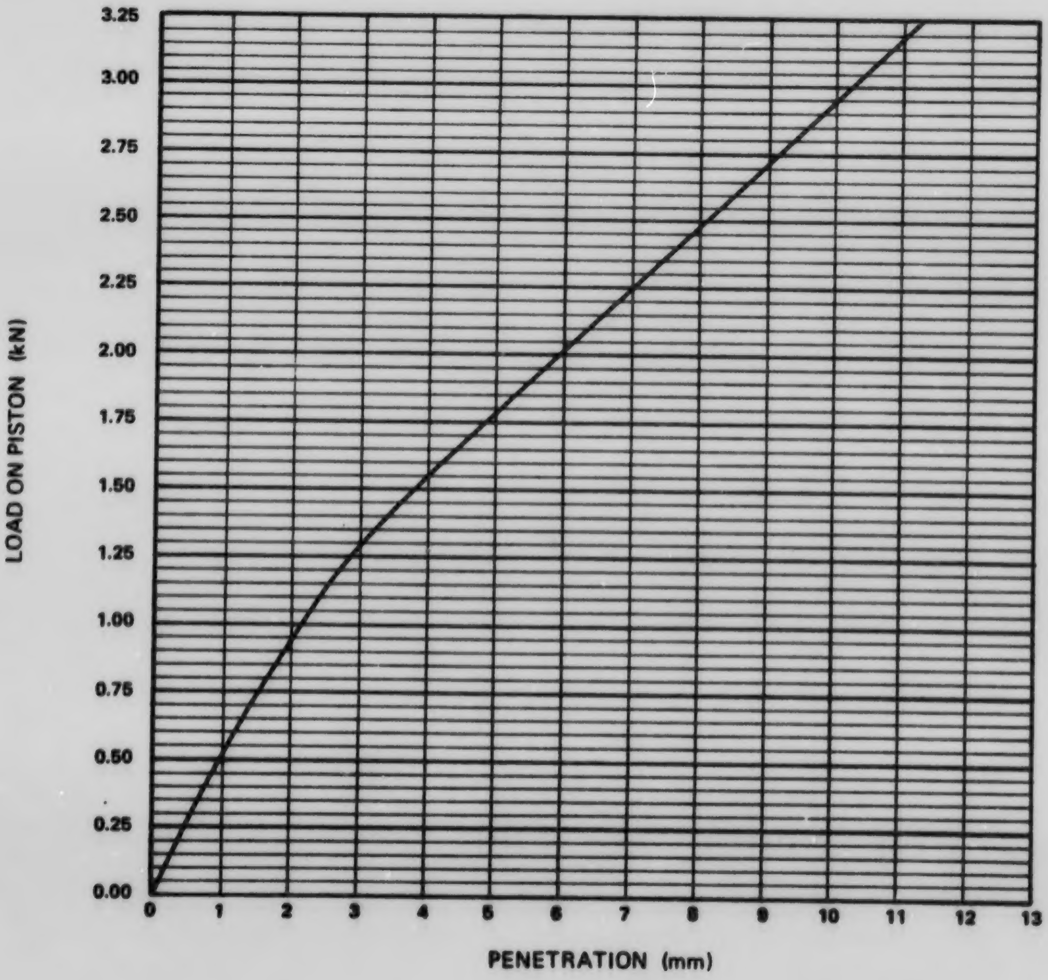
FLYASH 16 %

CEMENT 6 %

California Bearing Ratio: 2.5 mm 9.0 %

5.0 mm 9.0 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 100% of standard compactive effort, then cured at 20° C and 100% humidity for 7 days.



WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Project No.: 314 · 1264.02

Sample: Pincher Creek II

Sand 3 %, Silt 44 %, Clay 53 %

Stabilizer Dosage: FUJIBETON ____ %

FLYASH 12 %

CEMENT 3 %

Contract No.: 1 SD 83 · 00026

Design Maximum Dry Density: 1529 kg/m³

Design Optimum Moisture Content:% 20.0 %

Initial Dry Density: 1446 kg/m³

Initial Moisture Content: 19.9 %

Initial Volume: 942.1 cm³

Volume After Curing: 1022.2 cm³

Final Moisture Content: 34.8 %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 559 · 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm³)	VOLUME AFTER DRYING AND BRUSHING (cm³)	WEIGHT AFTER DRYING AND BRUSHING (g)
1	1019.4		
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during first drying period.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1525 kg/m^3

Sample: Pincher Creek II

Design Optimum Moisture Content:% 20.0 %

Sand 3 %, Silt 44 %, Clay 53 %

Initial Dry Density: 1454.4 kg/m^3

Initial Moisture Content: 19.1 %

Initial Volume: 957.5 cm^3

Stabilizer Dosage: FUJIBETON %

Volume After Curing: 1049.7 cm^3

FLYASH 12 %

Final Moisture Content: 36.9 %

CEMENT 4 %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 559 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm^3)	VOLUME AFTER DRYING AND BRUSHING (cm^3)	WEIGHT AFTER DRYING AND BRUSHING (g)
1	1034.8		
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during first drying period.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1499 kg/m^3

Sample: Pincher Creek II

Sand 3 %, Silt 44 %, Clay 53 %

Design Optimum Moisture Content:% 25.0 %

Initial Dry Density: 1422.4 kg/m^3

Initial Moisture Content: 24.4 %

Initial Volume: 922.4 cm^3

Stabilizer Dosage: FUJIBETON ___ %

Volume After Curing: 946.7 cm^3

FLYASH 12 %

Final Moisture Content: --- %

CEMENT 5 %

Stabilized Soil Loss: 30 %

Method of Sample Preparation: ASTM D 559 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm^3)	VOLUME AFTER DRYING AND BRUSHING (cm^3)	WEIGHT AFTER DRYING AND BRUSHING (g)
1	928.5	922.7	1433.4
2	922.4	903.2	1364.1
3	912.1	821.4	1324.8
4	888.3	884.7	1255.3
5	881.3	865.9	1237.7
6	900.0	859.3	1194.2
7	873.3	837.2	1141.1
8	879.3	776.3	1125.3
9	780.5	833.9	1098.4
10	760.5	695.3	1050.0
11	776.9	750.8	1029.6
12	777.1	728.5	979.3

Remarks: Unconfined Compressive Strength after durability test determined as 0.48 MPa.

EBA Engineering Consultants Ltd.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1544 kg/m3

Sample: Pincher Creek II

Sand 3 %, Silt 44 %, Clay 53 %

Design Optimum Moisture Content:% 20.0 %

Initial Dry Density: 1469 kg/m3

Initial Moisture Content: 19.1 %

Initial Volume: 950.8 cm3

Stabilizer Dosage: FUJIBETON %

FLYASH 12 %

CEMENT 6 %

Volume After Curing: 1020.6 cm3

Final Moisture Content: 41.1 %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 559 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm^3)	VOLUME AFTER DRYING AND BRUSHING (cm^3)	WEIGHT AFTER DRYING AND BRUSHING (g)
1	1019.8		
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during first drying period.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client:	TRANSPORT CANADA	Contract No.:	1 SD 83 - 00026
Project No.:	314 - 1264.02	Design Maximum Dry Density:	1534 kg/m3
Sample:	Pincher Creek II	Design Optimum Moisture Content:%	20.0 %
	Sand 3 %, Silt 44 %, Clay 53 %	Initial Dry Density:	1427 kg/m3
		Initial Moisture Content:	20.7 %
		Initial Volume:	960.4 cm3
Stabilizer Dosage: FUJIBETON	%	Volume After Curing:	997.8 cm3
FLYASH	12 %	Final Moisture Content:	36.2 %
CEMENT	7 %	Stabilized Soil Loss:	100 %

Method of Sample Preparation: ASTM D 559 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm3)	VOLUME AFTER DRYING AND BRUSHING (cm3)	WEIGHT AFTER DRYING AND BRUSHING (g)
1	998.8		
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during first drying period.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA	Contract No.: 1 SD 83 - 00026
Project No.: 314 - 1264.02	Design Maximum Dry Density: 1520 kg/m³
Sample: Pincher Creek II	Design Optimum Moisture Content:% 20.0 %
Sand 3 %, Silt 44 %, Clay 53 %	Initial Dry Density: 1448 kg/m³
	Initial Moisture Content: 19.2 %
	Initial Volume: 945.4 cm³
Stabilizer Dosage: FUJIBETON ____ %	Volume After Curing: 1021.7 cm³
FLYASH 14 %	Final Moisture Content: 36.8 %
CEMENT 6 %	Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 559 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm³)	VOLUME AFTER DRYING AND BRUSHING (cm³)	WEIGHT AFTER DRYING AND BRUSHING (g)
1	1022.4		
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during first drying period.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1539 kg/m3

Sample: Pincher Creek II

Design Optimum Moisture Content:%: 20.0 %

Sand 3 %, Silt 44 %, Clay 53 %

Initial Dry Density: 1457.6 kg/m3

Initial Moisture Content: 19.7 %

Initial Volume: 960.1 cm3

Stabilizer Dosage: FUJIBETON %

Volume After Curing: 1041.1 cm3

FLYASH 14 %

Final Moisture Content: 31.4 %

CEMENT 7 %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 559 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm3)	VOLUME AFTER DRYING AND BRUSHING (cm3)	WEIGHT AFTER DRYING AND BRUSHING (g)
1	1039.4		
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during first drying period.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client:	TRANSPORT CANADA	Contract No.:	1 SD 83 - 00026
Project No.:	314 - 1264.02	Design Maximum Dry Density:	1555 kg/m³
Sample:	Pincher Creek II	Design Optimum Moisture Content:%	20.0 %
	Sand 3 %, Silt 44 %, Clay 53 %	Initial Dry Density:	1481 kg/m³
		Initial Moisture Content:	19.0 %
		Initial Volume:	935.4 cm³
Stabilizer Dosage: FUJIBETON	%	Volume After Curing:	990.0 cm³
FLYASH	16 %	Final Moisture Content:	25.4 %
CEMENT	6 %	Stabilized Soil Loss:	100 %

Method of Sample Preparation: ASTM D 559 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm³)	VOLUME AFTER DRYING AND BRUSHING (cm³)	WEIGHT AFTER DRYING AND BRUSHING (g)
1	988.3	962.4	1472.5
2	963.5	814.4	1323.0
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during handling after third inundation.

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1530.0 kg/m3

Sample: Pincher Creek II

Sand 3 %, Silt 44 %, Clay 53 %

Design Optimum Moisture Content: 20.0 %

Initial Dry Density: 1436.8 kg/m3

Initial Moisture Content: 19.9 %

Initial Volume: 944.1 cm3

Stabilizer Dosage: FUJIBETON %

FLYASH 12 %

CEMENT 3 %

Volume After Curing: 1033.5 cm3

Final Moisture Content: 35.2 %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 560 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm3)	WEIGHT AFTER THAWING AND BRUSHING (g)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated during first thawing period.

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1524.9 kg/m^3

Sample: Pincher Creek II

Design Optimum Moisture Content: 20.0 %

Sand 3 %, Silt 44 %, Clay 53 %

Initial Dry Density: 1443.2 kg/m^3

Initial Moisture Content: 19.9 %

Initial Volume: 932.9 cm^3

Stabilizer Dosage: FUJIBETON ____ %

Volume After Curing: 996.7 cm^3

FLYASH 12 %

Final Moisture Content: 31.7 %

CEMENT 4 %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 560 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm^3)	WEIGHT AFTER THAWING AND BRUSHING (g)
1	974.4	1673.8
2	782.2	1325.5
3	535.8	992.4
4		
5		
6		
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated during brushing after fourth thawing period.

EBA Engineering Consultants Ltd.

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1499.3 kg/m^3

Sample: Pincher Creek II

Sand 3 %, Silt 44 %, Clay 53 %

Design Optimum Moisture Content: 25.0 %

Initial Dry Density: 1428.8 kg/m^3

Initial Moisture Content: 23.9 %

Initial Volume: 945.0 cm^3

Stabilizer Dosage: FUJIBETON ____ %

FLYASH 12 %

CEMENT 5 %

Volume After Curing: 976.6 cm^3

Final Moisture Content: 35.6 %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 560 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm^3)	WEIGHT AFTER THAWING AND BRUSHING (g)
1	958.4	1737.7
2	903.6	1642.1
3	838.9	1447.7
4	717.4	1257.0
5	588.7	1035.4
6	557.8	874.4
7	495.9	776.4
8	373.4	632.8
9	323.7	549.3
10	294.0	475.5
11	235.2	410.5
12	---	---

Remarks: Sample disintegrated during brushing after twelfth thawing period.

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1544.3 kg/m3

Sample: Pincher Creek II

Design Optimum Moisture Content: 20.0 %

Sand 3 %, Silt 44 %, Clay 53 %

Initial Dry Density: 1475.3 kg/m3

Initial Moisture Content: 18.8 %

Initial Volume: 939.3 cm3

Stabilizer Dosage: FUJIBETON %

Volume After Curing: 1009.8 cm3

FLYASH 12 %

Final Moisture Content: 34.0 %

CEMENT 6 %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 560 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm3)	WEIGHT AFTER THAWING AND BRUSHING (g)
1	1001.2	1720.4
2	864.1	1566.0
3	735.4	1209.4
4	553.1	1006.2
5	467.5	789.0
6		
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated during sixth thawing period.

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1535 kg/m3

Sample: Pincher Creek II

Sand 3 %, Silt 44 %, Clay 53 %

Design Optimum Moisture Content: 20.0 %

Initial Dry Density: 1448.0 kg/m3

Initial Moisture Content: 20.3 %

Initial Volume: 940.1 cm3

Stabilizer Dosage: FUJIBETON ___ %

FLYASH 12 %

CEMENT 7 %

Volume After Curing: 990.1 cm3

Final Moisture Content: 33.6 %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 560 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm3)	WEIGHT AFTER THAWING AND BRUSHING (g)
1	977.5	1742.4
2	895.1	1542.4
3	820.3	1306.0
4	649.4	1056.7
5	528.3	875.2
6	408.4	717.6
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated during seventh thawing period

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client:	TRANSPORT CANADA	Contract No.:	1 SD 83 - 00026
Project No.:	314 - 1264.02	Design Maximum Dry Density:	1520 kg/m³
Sample:	Pincher Creek II	Design Optimum Moisture Content:	20.0 %
	Sand 3 %, Silt 44 %, Clay 53 %	Initial Dry Density:	1436.8 kg/m³
		Initial Moisture Content:	20.2 %
		Initial Volume:	925.0 cm³
Stabilizer Dosage: FUJIBETON	%	Volume After Curing:	972.9 cm³
FLYASH	14 %	Final Moisture Content:	30.8 %
CEMENT	6 %	Stabilized Soil Loss:	100 %

Method of Sample Preparation: ASTM D 560 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm³)	WEIGHT AFTER THAWING AND BRUSHING (g)
1	948.6	1724.6
2	880.3	1526.7
3	797.5	1322.6
4	661.7	1115.5
5	521.6	883.7
6	408.0	717.0
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated during seventh thawing period

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1540 kg/m^3

Sample: Pincher Creek II

Sand 3 %, Silt 44 %, Clay 53 %

Design Optimum Moisture Content: 20.0 %

Initial Dry Density: 1452.3 kg/m^3

Initial Moisture Content: 20.1 %

Initial Volume: 964.0 cm^3

Volume After Curing: 1055.3 cm^3

Final Moisture Content: 35.1 %

Stabilized Soil Loss: 100 %

Stabilizer Dosage:
- FUJIBETON ____ %
- FLYASH 14 %
- CEMENT 7 %

Method of Sample Preparation: ASTM D 560 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm^3)	WEIGHT AFTER THAWING AND BRUSHING (g)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated during first thawing period

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Project No.: 314 · 1264.02

Sample: Pincher Creek II

Sand 3 %, Silt 44 %, Clay 53 %

Stabilizer Dosage: FUJIBETON %

FLYASH 16 %

CEMENT 6 %

Contract No.: 1 SD 83 · 00026

Design Maximum Dry Density: 1475.3 kg/m³

Design Optimum Moisture Content: 19.7 %

Initial Dry Density: 1475 kg/m³

Initial Moisture Content: 19.7 %

Initial Volume: 944.5 cm³

Volume After Curing: 1012.9 cm³

Final Moisture Content: 33.5 %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 560 · 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm^3)	WEIGHT AFTER THAWING AND BRUSHING (g)
1	978.0	1794.2
2	892.8	1461.9
3	595.3	1096.3
4	499.3	827.4
5	349.2	597.8
6		
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated during sixth thawing period

APPENDIX E

LABORATORY TEST RESULTS
DRUMHELLER

EBA Engineering Consultants Ltd.

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1SD83 - 00026

Project No.: 314 - 1264.02

Sample: Drumheller

Sand 1%, Silt 30%, Clay 69%

Stabilizer Dosage: FUJIBETON 0 %

FLYASH 0 %

CEMENT 0 %

TEST DATA:

1) Method of Sample Preparation: ASTM D 558 - 57

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	12.5	1838
2	19.0	1232
3	24.5	1240
4	30.0	1150
5	39.3	1212

Design Field Optimum Moisture Content: 28.0 %

Design Field Maximum Dry Density: 1325 kg/m³

2) Method of Sample Preparation: ASTM D558 - 57, but using 19 blows to compact each layer instead of 25 blows

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	12.1	1310
2	18.5	1232
3	24.1	1170
4	33.5	1154
5	33.6	1265

Design Field Optimum Moisture Content: 34 %

Design Field Maximum Dry Density: 1265 kg/m³

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

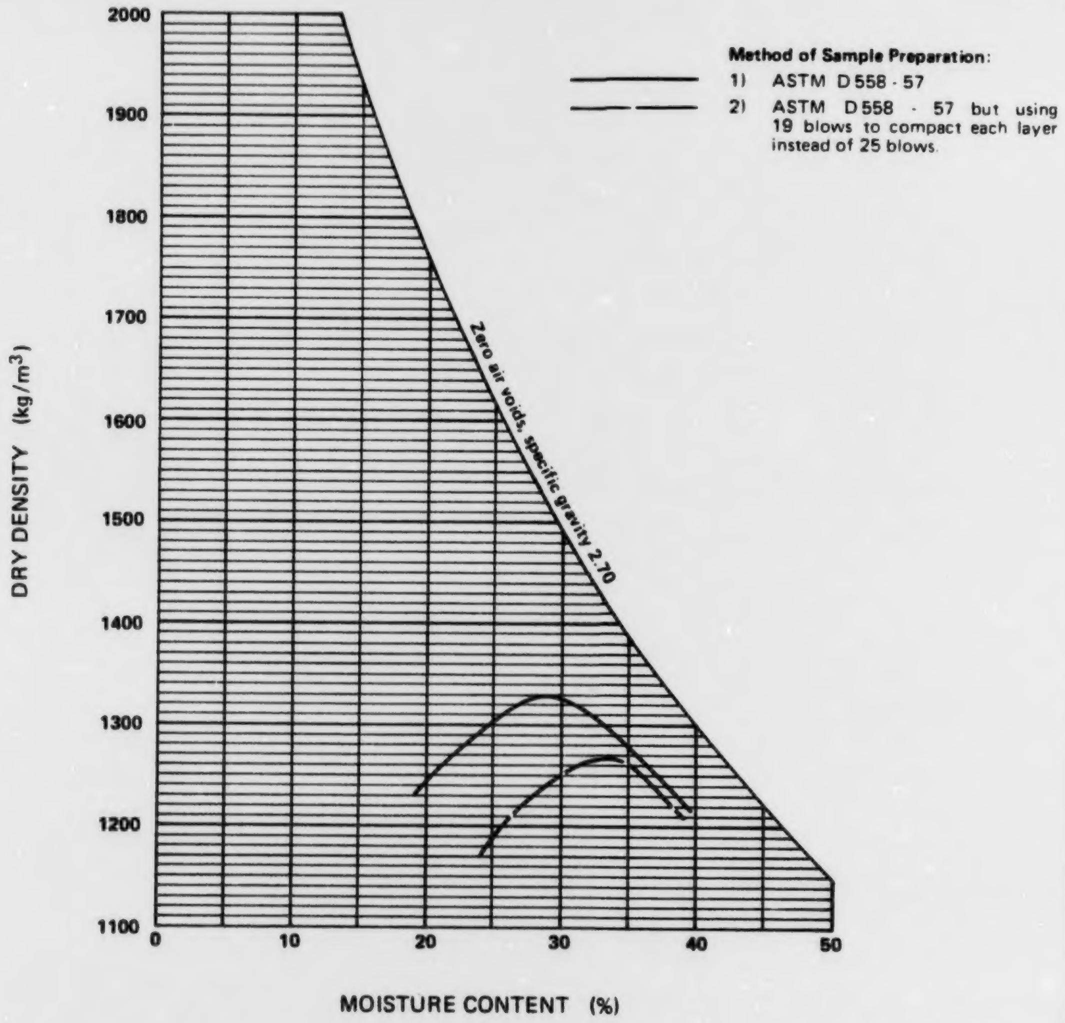
Stabilizer Dosage: FUJIBETON 0 %

FLYASH 0 %

CEMENT 0 %

Sample: Drumheller

Sand 1%, Silt 30%, Clay 69%



SHEET 2 OF 2

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1SD83 - 00026

Project No.: 314 - 1264.02

Stabilizer Dosage: FUJIBETON 0 %

FLYASH 0 %

CEMENT 0 %

Sample: Drumheller

Sand 1%, Silt 30%, Clay 69%

TEST DATA:

1) Method of Sample Preparation: ASTM D 558 - 57

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	11.0	1373
2	21.1	1210
3	26.0	1307
4	24.0	1270
5	29.6	1295

Design Field Optimum Moisture Content: 28.0 %

Design Field Maximum Dry Density: 1325 kg/m³

2) Method of Sample Preparation: ASTM D558 - 57, but using 19 blows to compact each layer instead of 25 blows

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	12.0	1257
2	18.6	1285
3	26.1	1140
4	31.2	1155
5	35.8	1194

Design Field Optimum Moisture Content: 34 %

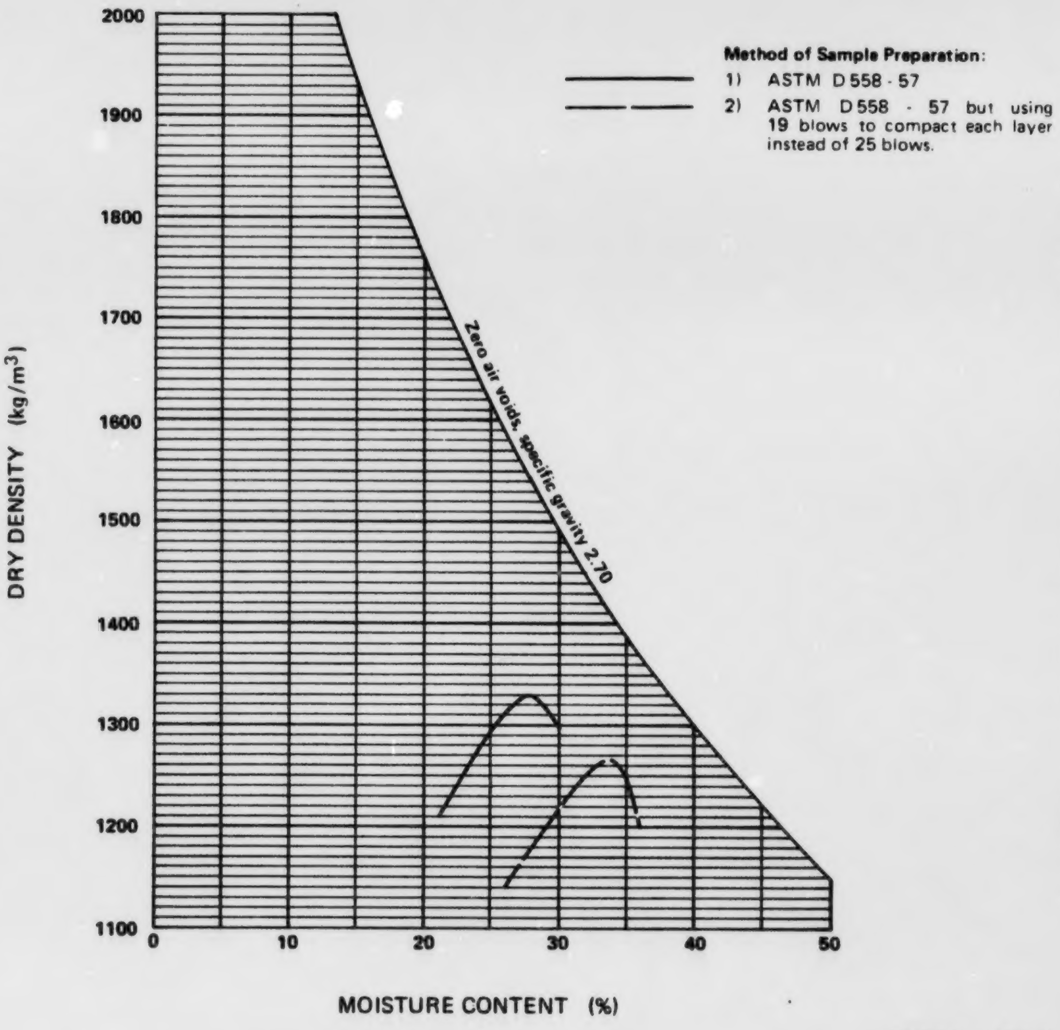
Design Field Maximum Dry Density: 1265 kg/m³

SHEET 1 OF 2

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client:	TRANSPORT CANADA	Contract No.:	1 SD 83 - 00026
Project No.:	314 - 1264.02	Stabilizer Dosage: FUJIBETON	0 %
Sample:	Drumheller	FLYASH	0 %
	Sand 1% , Silt 30% , Clay 69%	CEMENT	0 %



SHEET 2 OF 2

CALIFORNIA BEARING RATIO TEST

Project:	Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers		
Client:	TRANSPORT CANADA	Contract No.:	1 SD 83 - 00026
Project No.:	314 - 1264.02	Stabilizer Dosage:	None
Sample:	Drumheller		
	Sand 1% , Silt 30% , Clay 69%		

Samples compacted using 100% of standard energy

TEST	DRY DENSITY (kg/m³)	MOISTURE CONTENT (%)	CALIFORNIA BEARING RATIO (%)	
			2.5 mm Penetration	5.0 mm Penetration
1	1150	30.0	5.8	5.1
2	1212	39.3	6.0	4.6
3	1383	12.5	17	21
4	1232	19.0	13	13
5	1240	24.5	15	13
6	1373	11.0	26	24
7	1210	21.1	10	9.2
8	1307	26.0	7.3	6.3
9	1270	24.0	10	8.7
10	1295	29.6	9.5	7.4

CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02 Stabilizer Dosage: None

Sample: Drumheller

Sand 1%, Silt 30%, Clay 69%

Samples compacted using 75 % of standard energy

TEST	DRY DENSITY (kg/m^3)	MOISTURE CONTENT (%)	CALIFORNIA BEARING RATIO (%)	
			2.5 mm Penetration	5.0 mm Penetration
1	1232	18.5	11	12
2	1140	26.1	9.0	7.8
3	1170	24.1	11	7.8
4	1257	12.0	12	14
5	1310	12.1	12	14
6	1285	18.6	13	12
7	1194	35.8	4.0	3.0
8	1154	33.5	7.0	7.3
9	1155	31.2	8.3	7.8
10	1265	33.6	5.3	4.0

ATTERBERG LIMITS TEST DATA

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264. 02

SAMPLE	STABILIZER DOSAGE (%)			REACTION TIME (hours)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX
	FUJIBETON	FLYASH	CEMENT				
Drumheller	0	0	0	–	50.0	90.0	40.0
	0	0	0	–	54.0	92.5	38.5
	2	–	–	24	62.5	80.3	17.8
	2	–	–	48	35.4	70.0	34.6
	2	–	–	72	40.2	79.8	39.6
	5	–	–	24	43.5	73.0	29.5
	5	–	–	48	54.5	76.0	21.5
	5	–	–	72	–	–	Non Plastic
	6	–	–	24	–	–	Non Plastic
	8	–	–	24	–	–	Non Plastic
	8	–	–	48	–	–	Non Plastic
	8	–	–	72	–	–	Non Plastic
	12	–	–	24	–	–	Non Plastic
	12	–	–	48	–	–	Non Plastic
	12	–	–	72	–	–	Non Plastic
	16	–	–	24	–	–	Non Plastic
	16	–	–	48	–	–	Non Plastic
	16	–	–	72	–	–	Non Plastic
	–	2	–	24	37.0	73.0	36.0
	–	2	–	48	36.4	77.8	41.4
	–	2	–	72	36.4	76.4	40.0
	–	2	–	–**	34.2	79.9	45.7
	–	6	–	24	33.4	73.5	40.1
	–	6	–	48	34.5	77.0	42.5
	–	6	–	72	35.2	83.0	47.8
	–	6	–	–**	36.5	77.0	40.5

** – *Limits determined after durability test*

ATTERBERG LIMITS TEST DATA

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264. 02

SAMPLE	STABILIZER DOSAGE (%)			REACTION TIME (hours)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX
	FUJIBETON	FLYASH	CEMENT				
Drumheller	–	12	–	24	32.2	81.7	49.5
	–	12	–	48	33.3	77.9	44.6
	–	12	–	72	31.5	78.2	46.7
	–	16	–	24	31.4	89.5	58.1
	–	16	–	48	31.1	77.0	45.9
	–	16	–	72	30.0	73.3	43.3
	–	9	3	24	47.5	63.3	15.8
	–	9	3	48	–	–	Non Plastic
	–	9	3	72	–	–	Non Plastic

PAGE 2 OF 2

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1SD83 - 00026

Project No.: 314 - 1264.02

Stabilizer Dosage: FUJIBETON 2 %

FLYASH %

CEMENT %

Sample: Drumheller

Sand 1%, Silt 30%, Clay 69%

TEST DATA:

1) Method of Sample Preparation: ASTM D 558 - 57

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	20.4	1261
2	25.4	1255
3	29.0	1263
4	32.6	1266
5	40.6	1211

Design Field Optimum Moisture Content: 30 %

Design Field Maximum Dry Density: 1270 kg/m³

2) Method of Sample Preparation: ASTM D558 - 57, but using 19 blows to compact each layer instead of 25 blows

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	28.9	1284
2	27.1	1293
3	27.1	1296
4	44.8	1179
5		

Design Field Optimum Moisture Content: 32 %

Design Field Maximum Dry Density: 1295 kg/m³

SHEET 1 OF 2

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

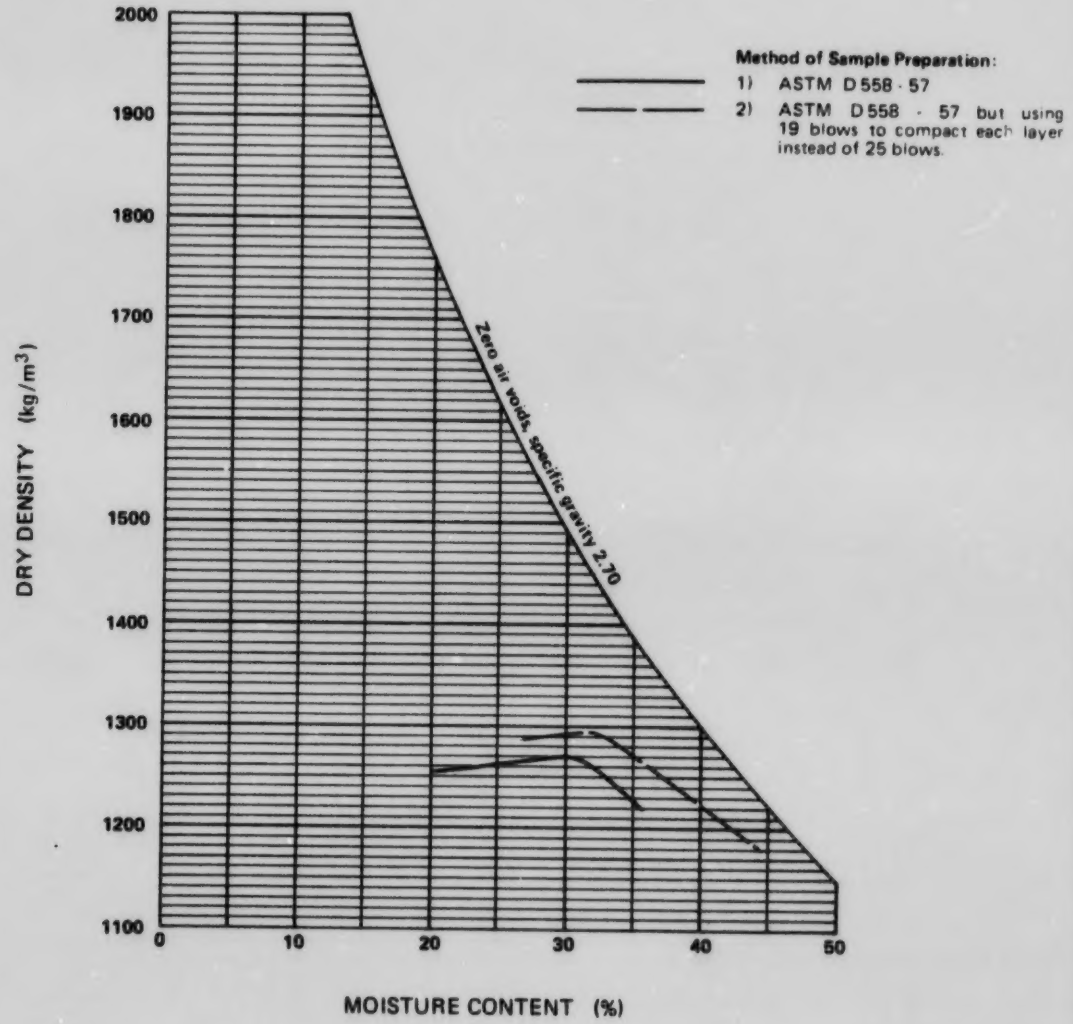
Stabilizer Dosage: FUJIBETON 2 %

Sample: Drumheller

FLYASH %

Sand 1 %, Silt 30 %, Clay 69 %

CEMENT %



DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1SD83 - 00026

Project No.: 314 - 1264.02

Stabilizer Dosage: FUJIBETON 5 %

Sample: Drumheller

FLYASH %

Sand 1%, Silt 30%, Clay 69%

CEMENT %

TEST DATA:

1) Method of Sample Preparation: ASTM D 558 - 57

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	8.9	1378
2	17.7	1333
3	31.6	1245
4	33.2	1301
5	22.8	1398

Design Field Optimum Moisture Content: 23 %

Design Field Maximum Dry Density: 1400 kg/m³

2) Method of Sample Preparation: ASTM D558 - 57, but using 19 blows to compact each layer instead of 25 blows

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	23.4	1235
2	20.6	1311
3	19.4	1308
4	31.6	1306
5		

Design Field Optimum Moisture Content: 30 %

Design Field Maximum Dry Density: 1300 kg/m³

SHEET 1 OF 2

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

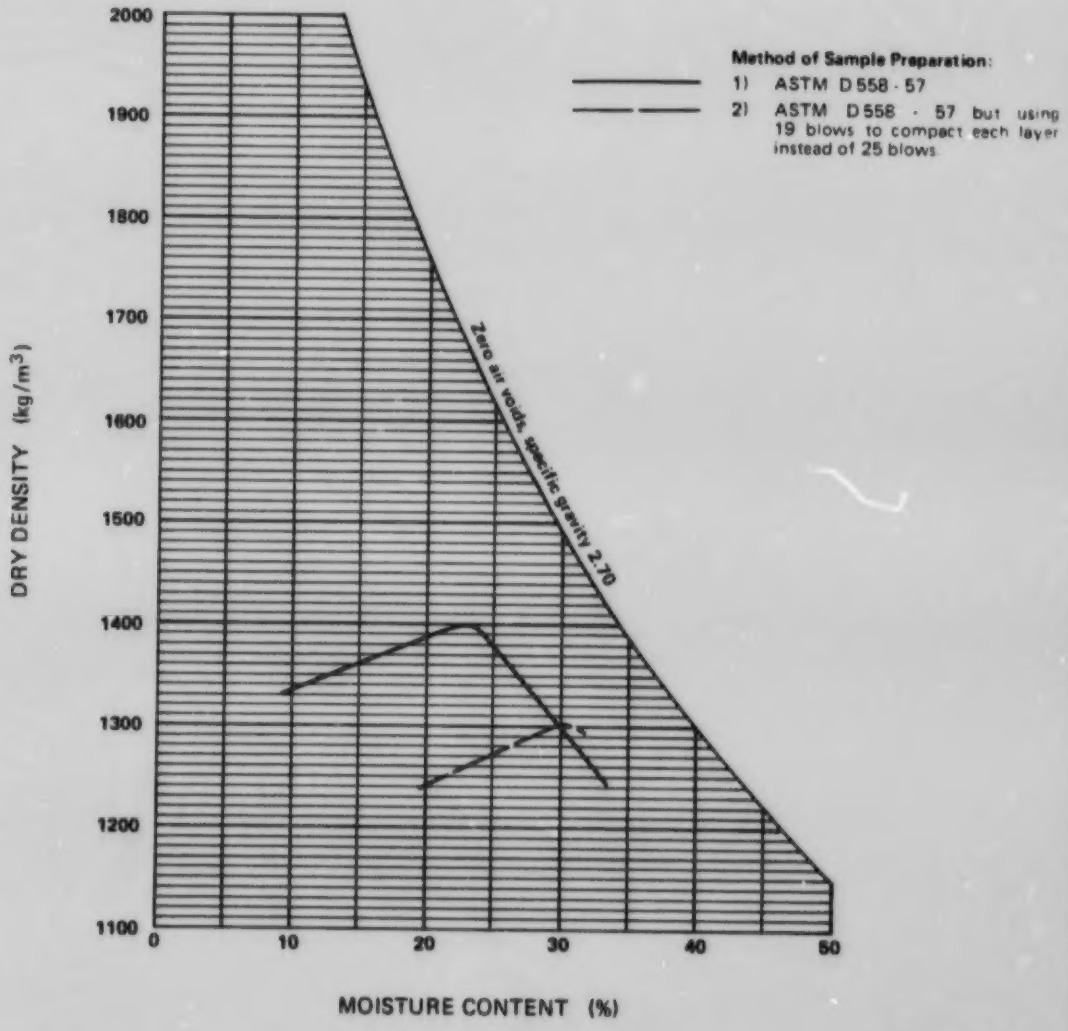
Stabilizer Dosage: FUJIBETON 5 %

FLYASH %

CEMENT %

Sample: Drumheller

Sand 1 %, Silt 30 %, Clay 69 %



SHEET 2 OF 2

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1SD83 - 00026

Project No.: 314 - 1264.02

Stabilizer Dosage: FUJIBETON 8 %

Sample: Drumheller

FLYASH %

Sand 1%, Silt 30%, Clay 69%

CEMENT %

TEST DATA:

1) Method of Sample Preparation: ASTM D 558 - 57

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m^3)
1	22.5	1285
2	26.1	1275
3	33.6	1273
4	39.0	1235
5	41.0	1209

Design Field Optimum Moisture Content: 33 %

Design Field Maximum Dry Density: 1280 kg/m^3

2) Method of Sample Preparation: ASTM D558 - 57, but using 19 blows to compact each layer instead of 25 blows

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m^3)
1	27.9	1310
2	27.0	1340
3	30.7	1258
4	41.8	1208
5		

Design Field Optimum Moisture Content: 27 %

Design Field Maximum Dry Density: 1340 kg/m^3

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

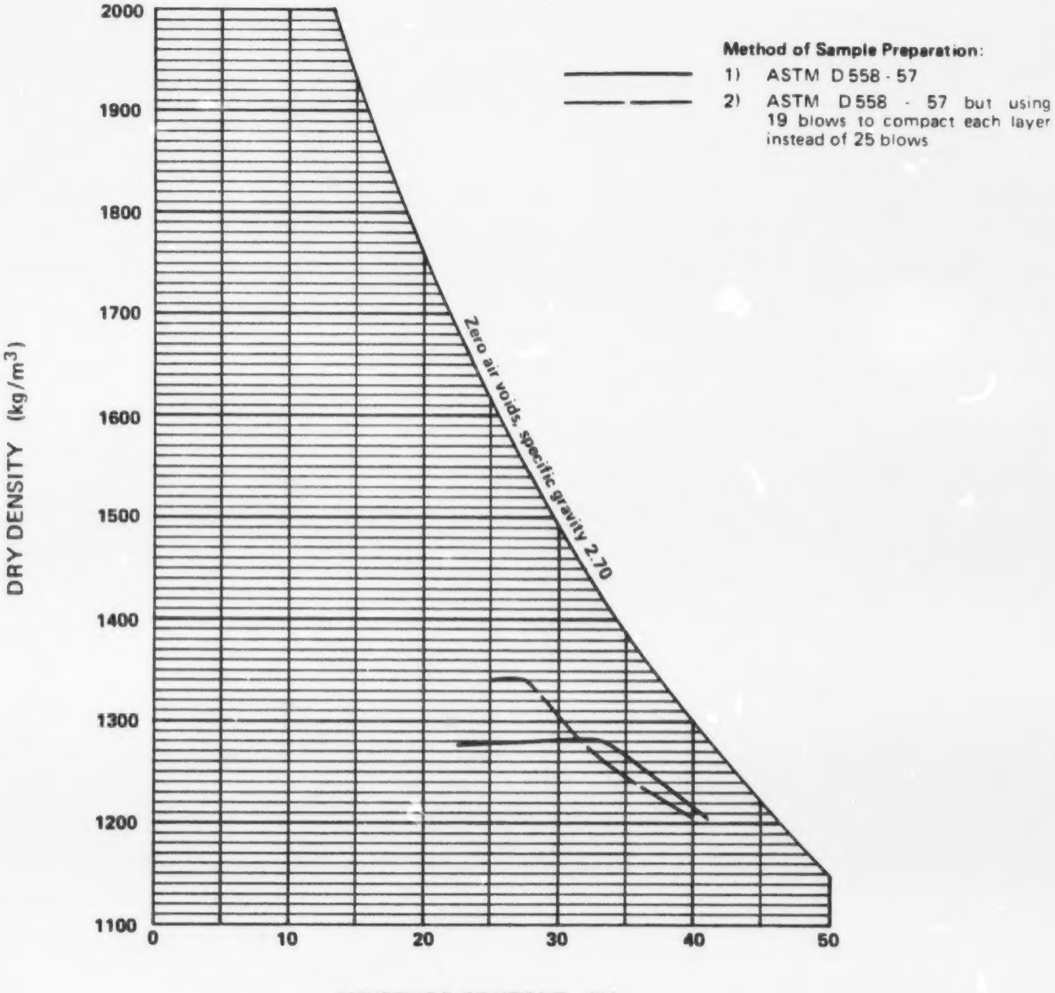
Stabilizer Dosage: FUJIBETON 8 %

FLYASH %

CEMENT %

Sample: Drumheller

Sand 1 %, Silt 30 %, Clay 69 %



DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA Contract No.: 1SD83 - 00026

Project No.: 314 - 1264.02 Stabilizer Dosage: FUJIBETON 12 %

Sample: Drumheller FLYASH %

Sand 1%, Silt 30%, Clay 69% CEMENT %

TEST DATA:

1) Method of Sample Preparation: ASTM D 558 - 57

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	13.0	1496
2	19.0	1418
3	22.4	1372
4	25.0	1317
5	5.8	1540

Design Field Optimum Moisture Content: 22 %

Design Field Maximum Dry Density: 1375 kg/m³

2) Method of Sample Preparation: ASTM D558 - 57, but using 19 blows to compact each layer instead of 25 blows

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	23.0	1333
2	19.8	1308
3	19.5	1346
4	32.7	1308
5		

Design Field Optimum Moisture Content: 25 %

Design Field Maximum Dry Density: 1340 kg/m³

SHEET 1 OF 2

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

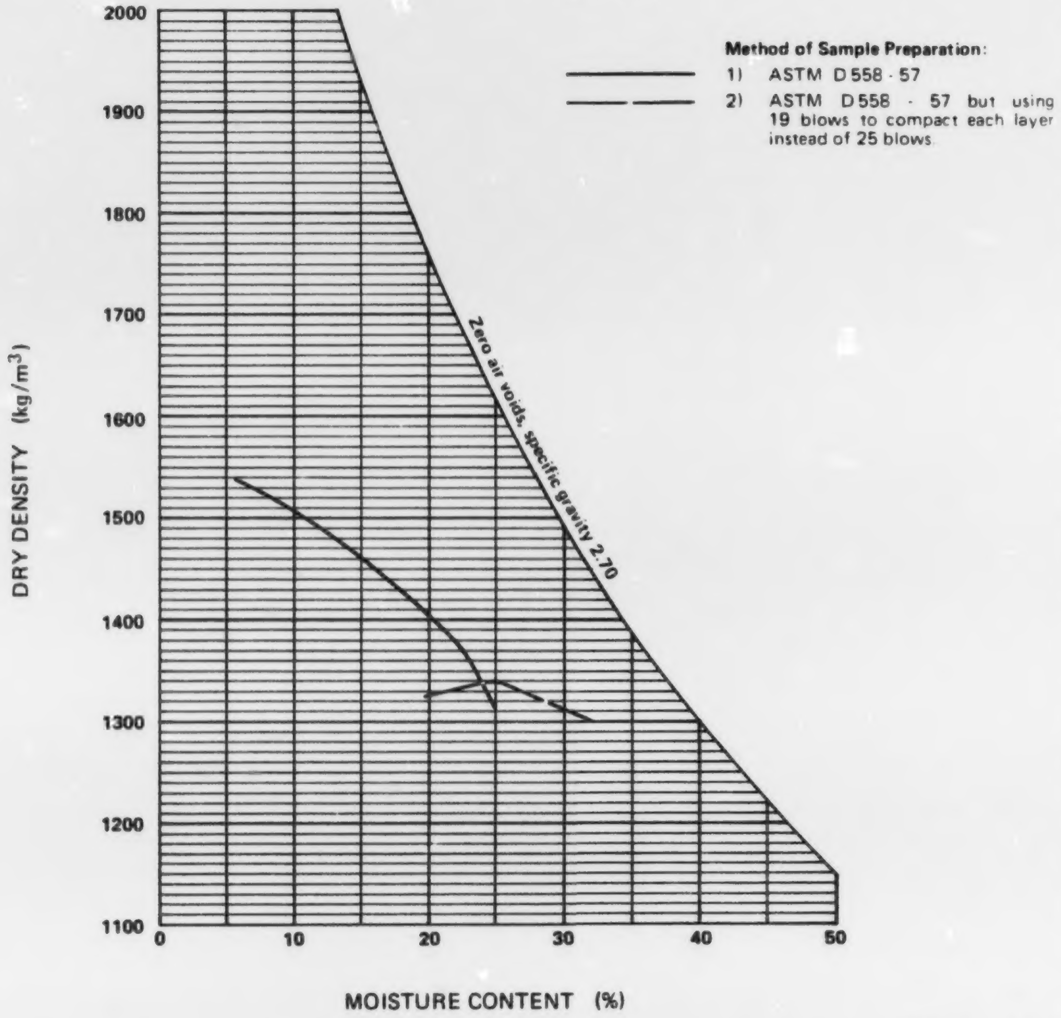
Stabilizer Dosage: FUJIBETON 12 %

FLYASH %

CEMENT %

Sample: Drumheller

Sand 1 %, Silt 30 %, Clay 69 %



SHEET 2 OF 2

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1SD83 - 00026

Project No.: 314 - 1264.02

Stabilizer Dosage: FUJIBETON ______ %

Sample: Drumheller

FLYASH 16 %

Sand 1%, Silt 30%, Clay 69%

CEMENT ______ %

TEST DATA:

1) Method of Sample Preparation: ASTM D 558 - 57

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m^3)
1	21.0	1374
2	25.6	1320
3	30.3	1340
4	34.6	1291
5	39.6	1245

Design Field Optimum Moisture Content: 30 %

Design Field Maximum Dry Density: 1340 kg/m^3

2) Method of Sample Preparation: ASTM D558 - 57, but using 19 blows to compact each layer instead of 25 blows

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m^3)
1	22.3	1358
2	25.3	1316
3	26.2	1283
4	27.2	1332
5		

Design Field Optimum Moisture Content: 27 %

Design Field Maximum Dry Density: 1340 kg/m^3

SHEET 1 OF 2

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

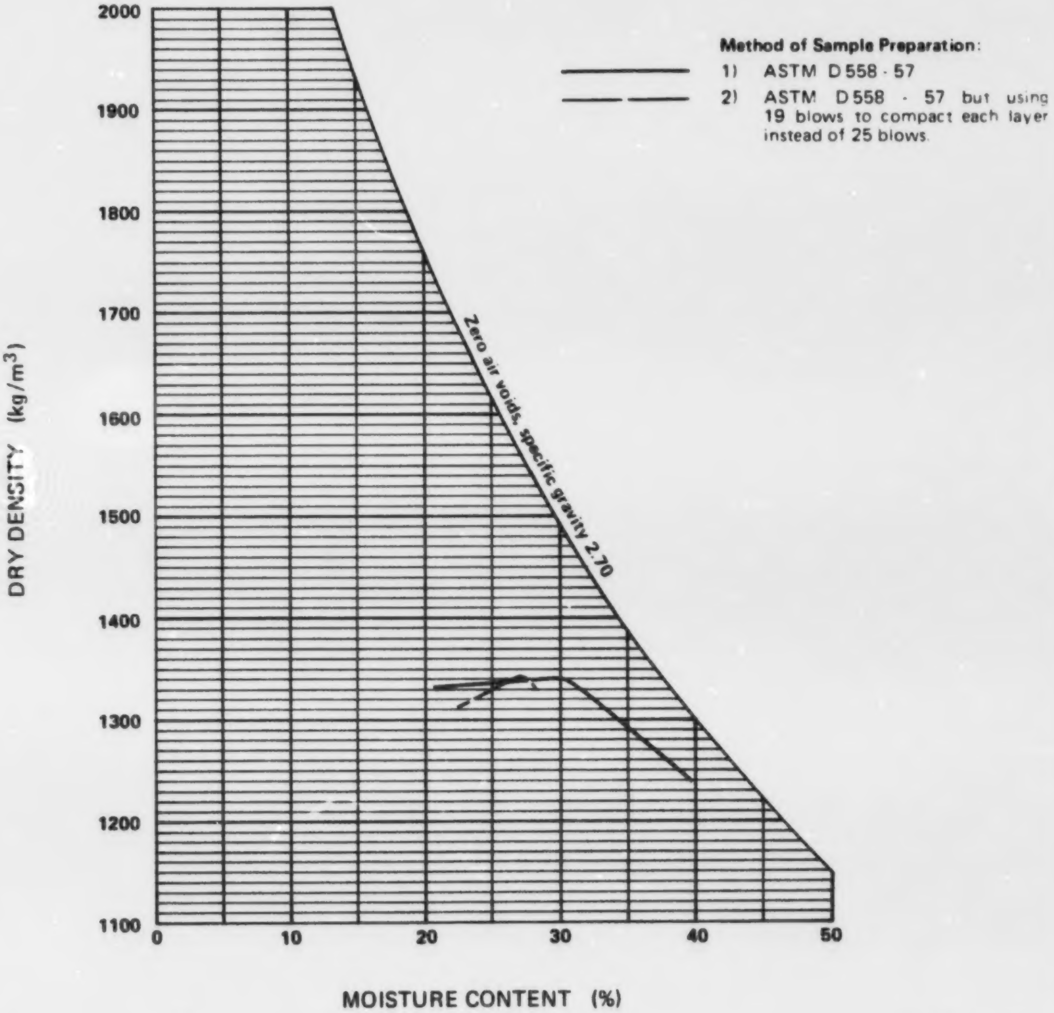
Stabilizer Dosage: FUJIBETON ______ %

FLYASH 16 %

CEMENT ______ %

Sample: Drumheller

Sand 1 %, Silt 30 %, Clay 69 %



SHEET 2 OF 2

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client:	TRANSPORT CANADA	Contract No.:	1SD83 - 00026
Project No.:	314 - 1264.02	Stabilizer Dosage: FUJIBETON	%
Sample:	Drumheller	FLYASH	2 %
Sand 1%, Silt 30%, Clay 69%		CEMENT	%

TEST DATA:

1) Method of Sample Preparation: ASTM D 558 - 57

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	27.4	1206
2	30.6	1255
3	38.5	1226
4	41.1	1192
5	21.7	1172

Design Field Optimum Moisture Content: 34 %

Design Field Maximum Dry Density: 1278 kg/m³

2) Method of Sample Preparation: ASTM D558 - 57, but using 19 blows to compact each layer instead of 25 blows

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	36.1	1278
2	31.7	1312
3	34.7	1229
4	46.1	1128
5		

Design Field Optimum Moisture Content: 36 %

Design Field Maximum Dry Density: 1280 kg/m³

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

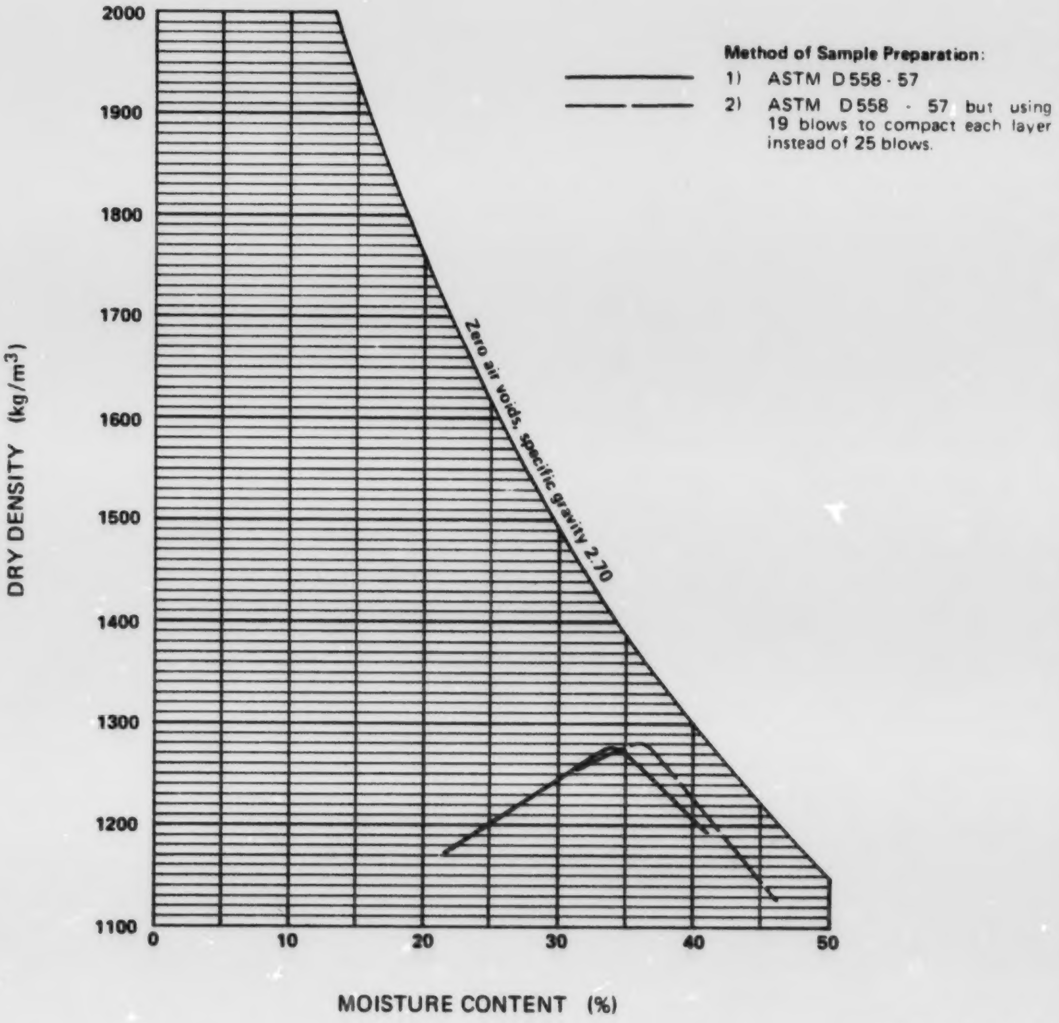
Stabilizer Dosage: FUJIBETON ____ %

Sample: Drumheller

FLYASH 2 %

Sand 1 %, Silt 30 %, Clay 69 %

CEMENT ____ %



SHEET 2 OF 2

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1SD83 - 00026

Project No.: 314 - 1264.02

Stabilizer Dosage: FUJIBETON %

FLYASH 6 %

CEMENT %

Sample: Drumheller

Sand 1%, Silt 30%, Clay 69%

TEST DATA:

1) Method of Sample Preparation: ASTM D 558 - 57

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m^3)
1	29.2	1235
2	23.5	1213
3	31.8	1240
4	37.4	1223
5	41.7	1186

Design Field Optimum Moisture Content: 33.3 %

Design Field Maximum Dry Density: 1246 kg/m^3

2) Method of Sample Preparation: ASTM D558 - 57, but using 19 blows to compact each layer instead of 25 blows

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m^3)
1	28.6	1347
2	30.7	1305
3	33.7	1229
4	47.9	1119
5		

Design Field Optimum Moisture Content: 30 %

Design Field Maximum Dry Density: 1320 kg/m^3

SHEET 1 OF 2

DRY DENSITY/MOISTURE CONTENT
RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

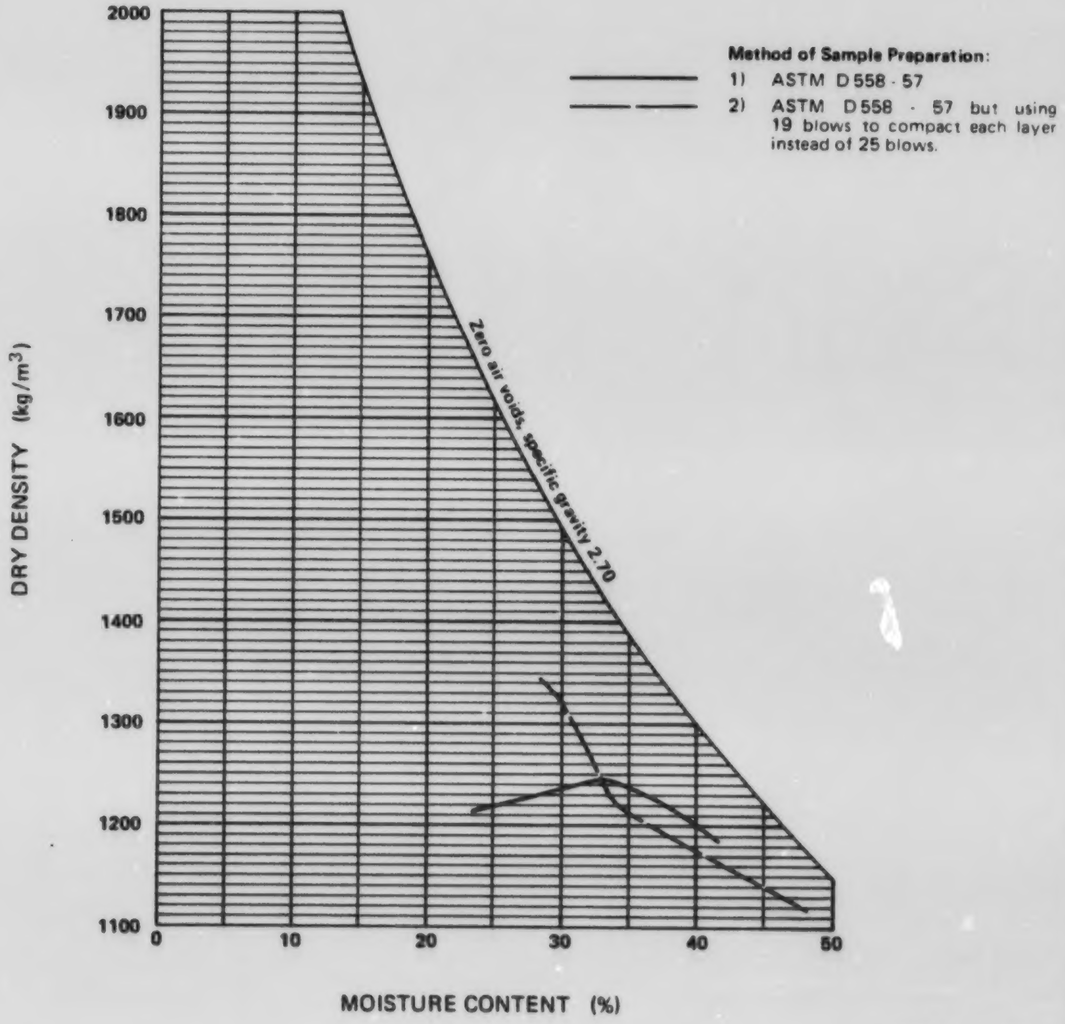
Stabilizer Dosage: FUJIBETON ______ %

Sample: Drumheller

FLYASH 6 %

Sand 1 %, Silt 30 %, Clay 69 %

CEMENT ______ %



EBA Engineering Consultants Ltd.

eba

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1SD83 - 00026

Project No.: 314 - 1264.02

Stabilizer Dosage: FUJIBETON ______ %

FLYASH 12 %

CEMENT ______ %

Sample: Drumheller

Sand 1%, Silt 30%, Clay 69%

TEST DATA:

1) Method of Sample Preparation: ASTM D 558 - 57

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	21.5	1284
2	24.3	1275
3	29.4	1301
4	34.3	1274
5	39.4	1196

Design Field Optimum Moisture Content: 30 %

Design Field Maximum Dry Density: 1305 kg/m³

2) Method of Sample Preparation: ASTM D558 - 57, but using 19 blows to compact each layer instead of 25 blows

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	23.5	1310
2	26.5	1250
3	30.3	1259
4	44.5	1143
5		

Design Field Optimum Moisture Content: 31 %

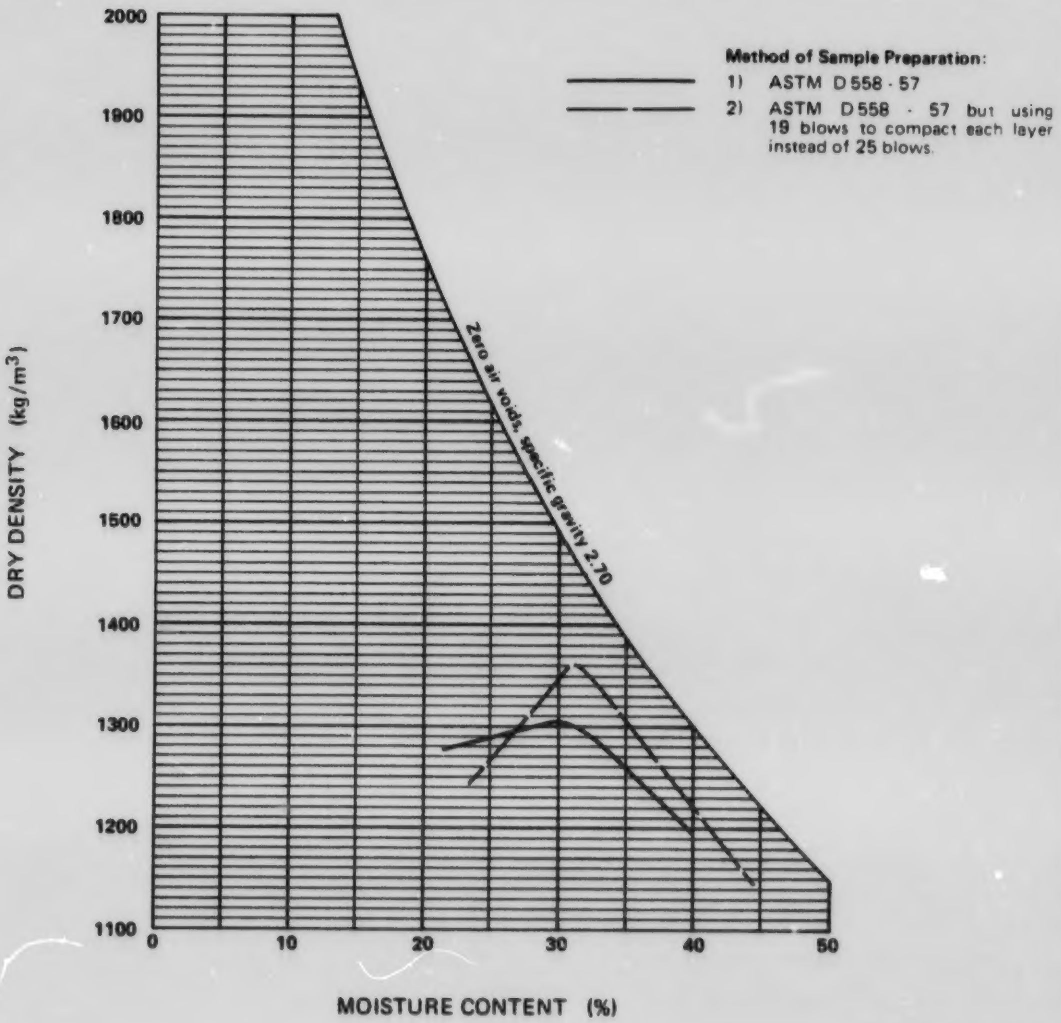
Design Field Maximum Dry Density: 1360 kg/m³

SHEET 1 OF 2

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client:	TRANSPORT CANADA	Contract No.:	1 SD 83 - 00026
Project No.:	314 - 1264.02	Stabilizer Dosage:	FUJIBETON ______ %
Sample:	Drumheller		FLYASH 12 %
	Sand 1 %, Silt 30 %, Clay 69 %		CEMENT ______ %



DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1SD83 - 00026

Project No.: 314 - 1264.02

Stabilizer Dosage: FUJIBETON ____ %

Sample: Drumheller

FLYASH 16 %

Sand 1%, Silt 30%, Clay 69%

CEMENT ____ %

TEST DATA:

1) Method of Sample Preparation: ASTM D 558 - 57

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	19.4	1350
2	23.8	1332
3	29.2	1317
4	35.3	1255
5	41.6	1172

Design Field Optimum Moisture Content: 30 %

Design Field Maximum Dry Density: 1315 kg/m³

2) Method of Sample Preparation: ASTM D558 - 57, but using 19 blows to compact each layer instead of 25 blows

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	26.0	1348
2	29.5	1268
3	30.3	1245
4	43.3	1158
5		

Design Field Optimum Moisture Content: 26 %

Design Field Maximum Dry Density: 1350 kg/m³

SHEET 1 OF 2

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

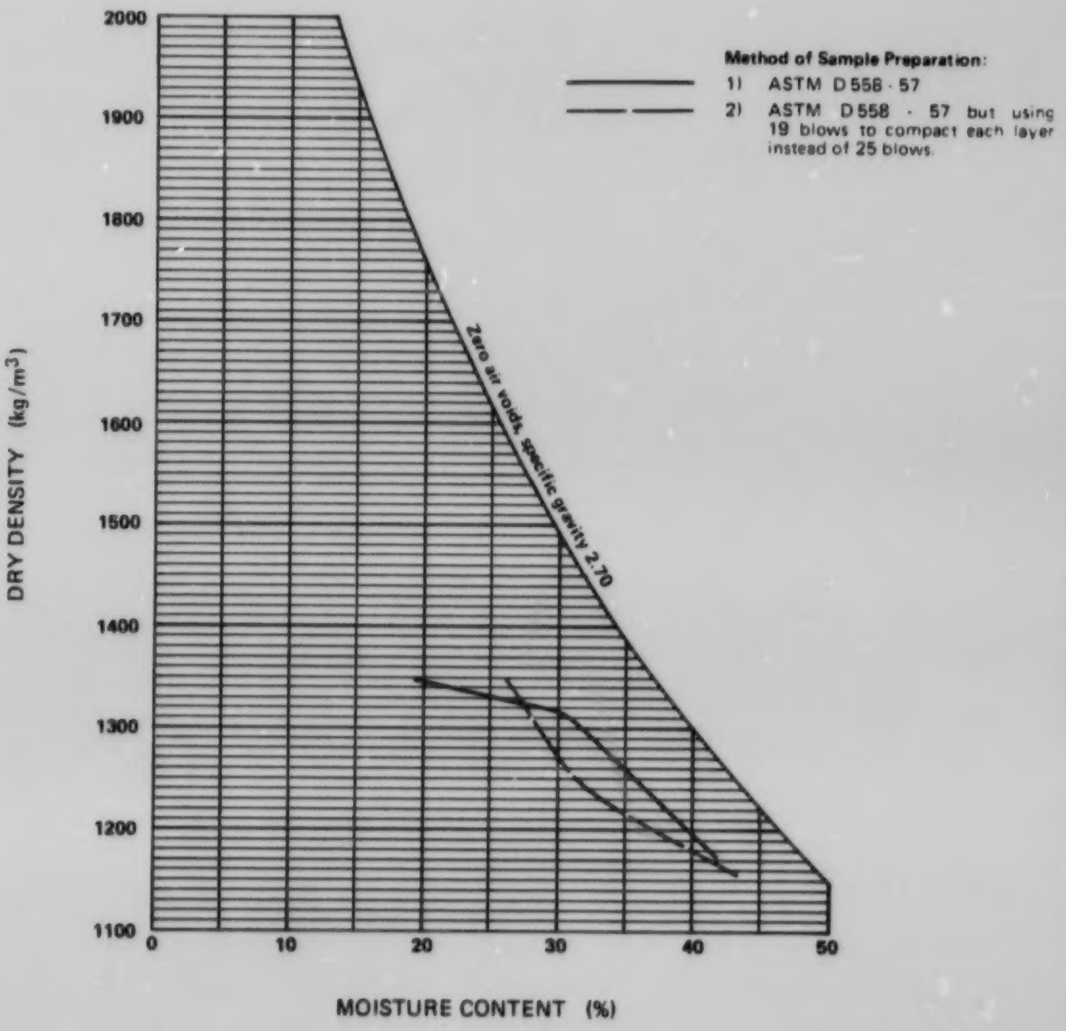
Stabilizer Dosage: FUJIBETON ______ %

Sample: Drumheller

FLYASH 16 %

Sand 1 %, Silt 30 %, Clay 69 %

CEMENT ______ %



SHEET 2 OF 2

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1SD83 - 00026

Project No.: 314 - 1264.02

Stabilizer Dosage: FUJIBETON ______ %

FLYASH 9 %

CEMENT 3 %

Sample: Drumheller

Sand 1%, Silt 30%, Clay 69%

TEST DATA:

1) Method of Sample Preparation: ASTM D 558 - 57

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m^3)
1	13.2	1429
2	17.2	1382
3	20.9	1381
4	25.2	1365
5	29.5	1341

Design Field Optimum Moisture Content: 30 %

Design Field Maximum Dry Density: 1350 kg/m^3

2) Method of Sample Preparation: ASTM D558 - 57, but using 19 blows to compact each layer instead of 25 blows

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m^3)
1	29.4	1333
2	28.1	1307
3	29.3	1300
4	45.0	1155
5		

Design Field Optimum Moisture Content: 30 %

Design Field Maximum Dry Density: 1335 kg/m^3

SHEET 1 OF 2

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

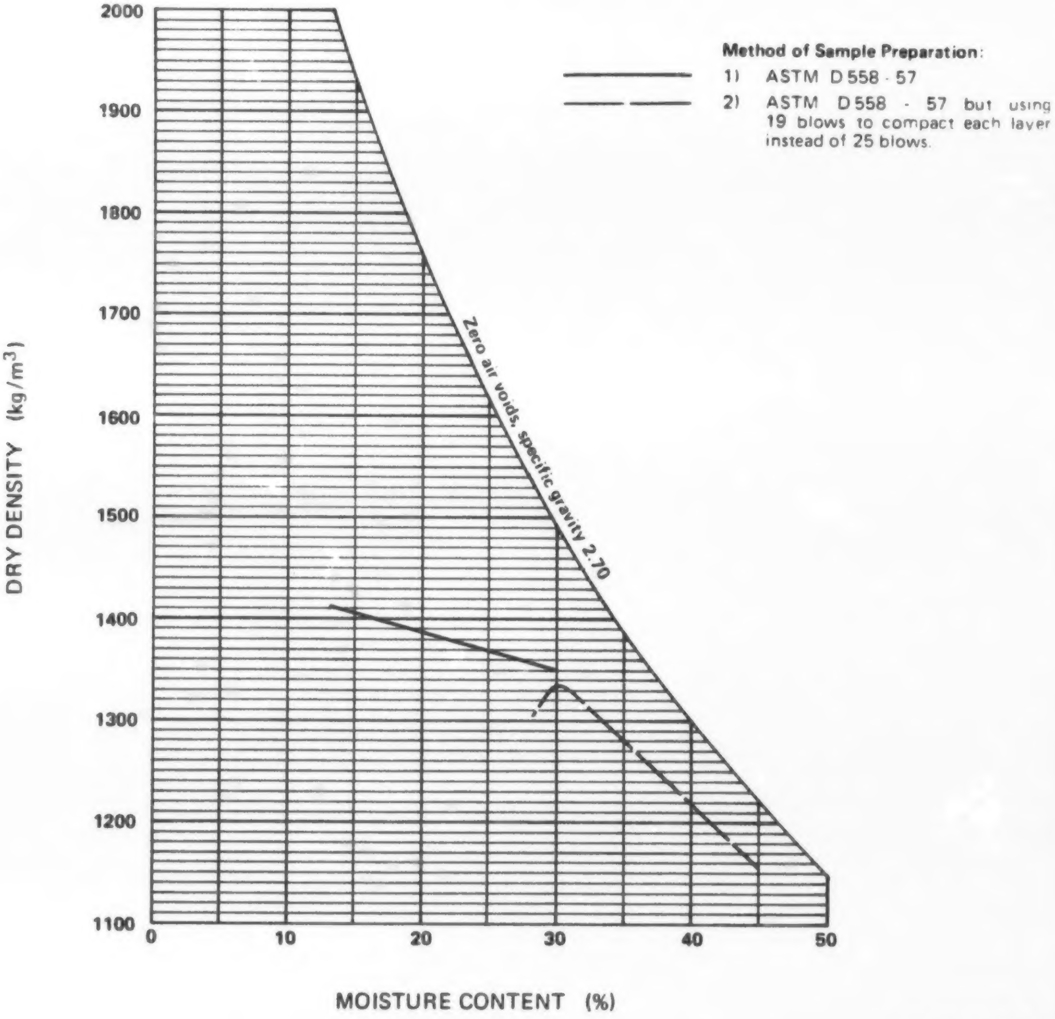
Stabilizer Dosage: FUJIBETON ______ %

FLYASH 9 %

CEMENT 3 %

Sample: Drumheller

Sand 1 %, Silt 30 %, Clay 69 %



SHEET 2 OF 2

CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 · 00026

Project No.: 314 · 1264.02

Sample: Drumheller

Sand 1% , Silt 30% , Clay 69%

Initial Dry Density: 1201 kg/m^3

Initial Moisture Content: 37.5 %

Stabilizer Dosage: FUJIBETON 2 %

Final Moisture Content: 38.4 %

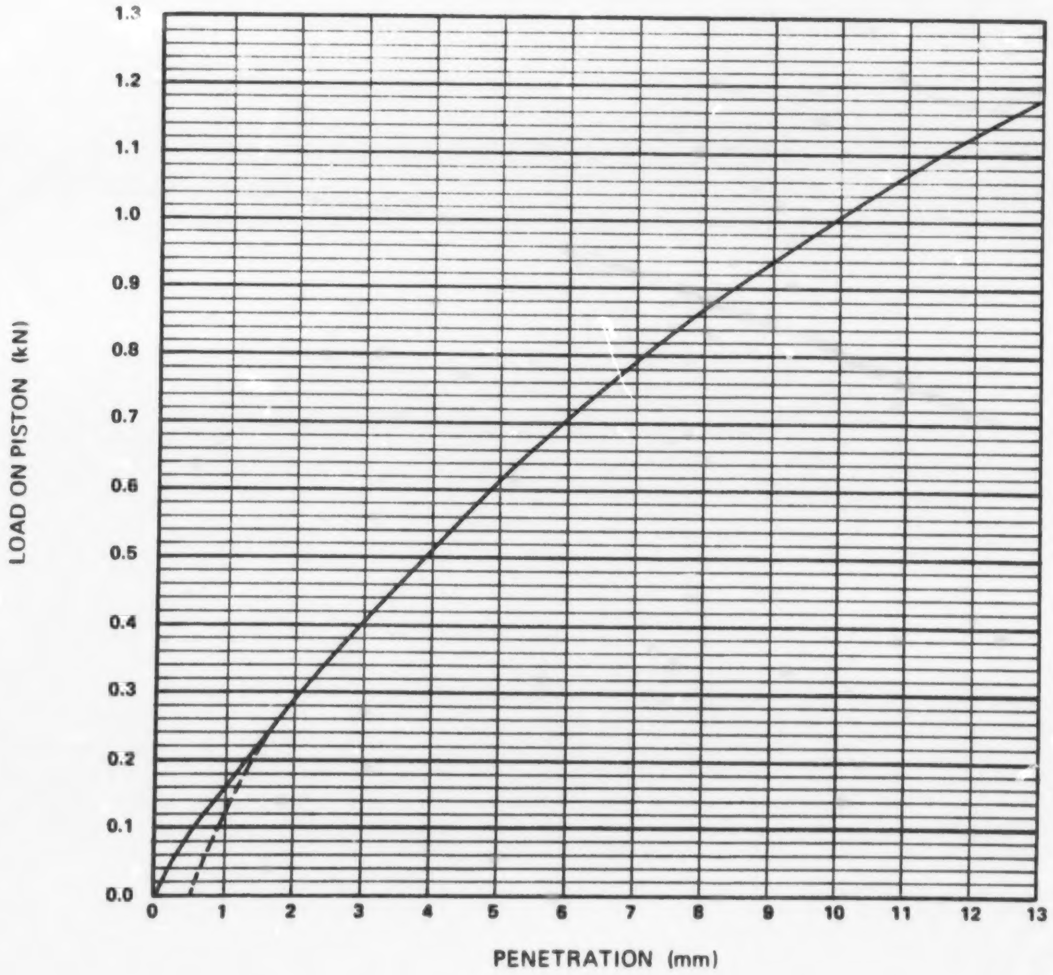
FLYASH %

California Bearing Ratio: 2.5 mm 3.1 %

CEMENT %

5.0 mm 3.3 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 100% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 · 00026

Project No.: 314 · 1264.02

Sample: Drumheller

Sand 1% , Silt 30% , Clay 69 %

Initial Dry Density: 1185 kg/m^3

Initial Moisture Content: 44.2 %

Stabilizer Dosage: FUJIBETON 2 %

Final Moisture Content: 46.6 %

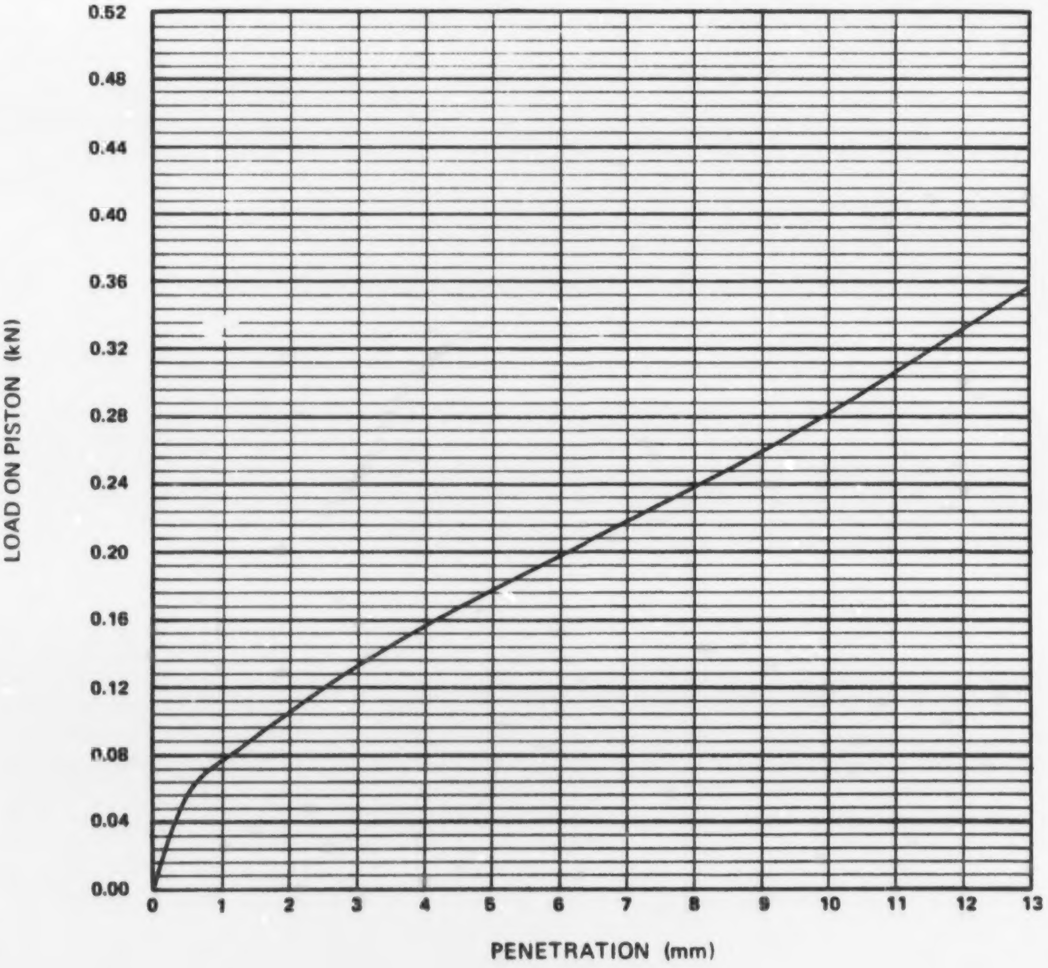
FLYASH %

California Bearing Ratio: 2.5 mm 0.9 %

CEMENT %

5.0 mm 0.9 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 75% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Drumheller

Sand 1%, Silt 30%, Clay 69%

Initial Dry Density: 1315 kg/m^3

Initial Moisture Content: 31.0 %

Stabilizer Dosage: FUJIBETON 5 %

Final Moisture Content: 30.5 %

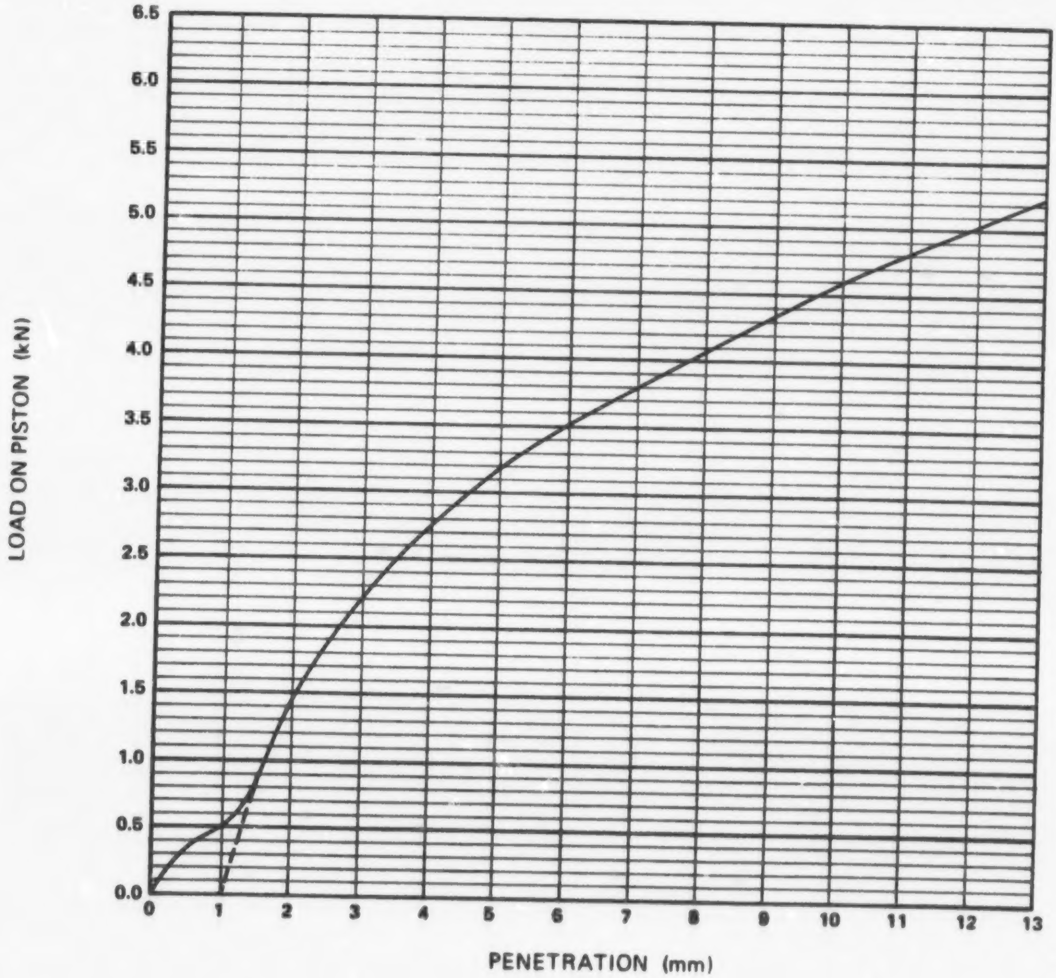
FLYASH %

California Bearing Ratio: 2.5 mm 19 %

CEMENT %

5.0 mm 18 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 100% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.

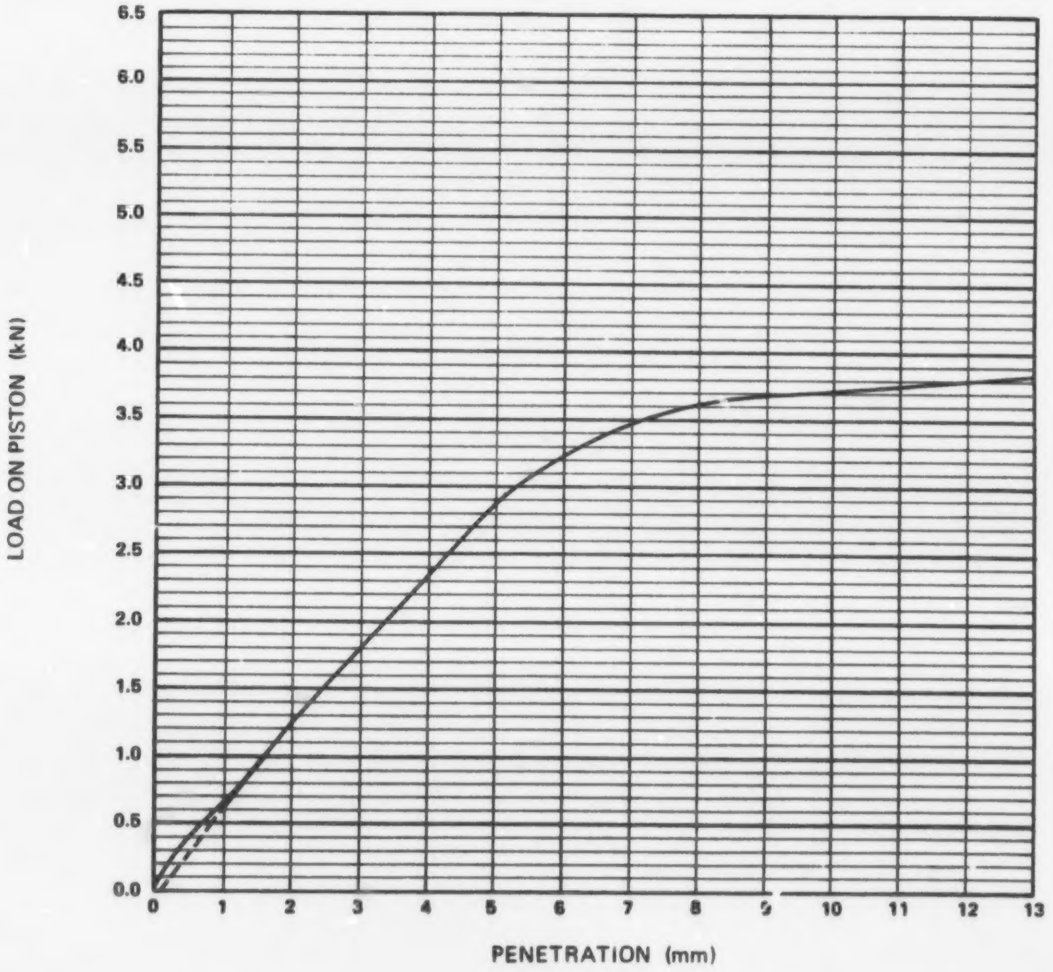


CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client:	TRANSPORT CANADA	Contract No.:	1 SD 83 - 00026
Project No.:	314 - 1264.02		
Sample:	Drumheller	Initial Dry Density:	1207 kg/m^3
	Sand 1%, Silt 30%, Clay 69%	Initial Moisture Content:	40.0 %
Stabilizer Dosage: FUJIBETON	5 %	Final Moisture Content:	46.7 %
FLYASH	%	California Bearing Ratio: 2.5 mm	12 %
CEMENT	%	5.0 mm	14 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 75% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Drumheller

Sand 1% , Silt 30% , Clay 69%

Initial Dry Density: 1188 kg/m^3

Initial Moisture Content: 43.4 %

Stabilizer Dosage: FUJIBETON 8 %

Final Moisture Content: 39.2 %

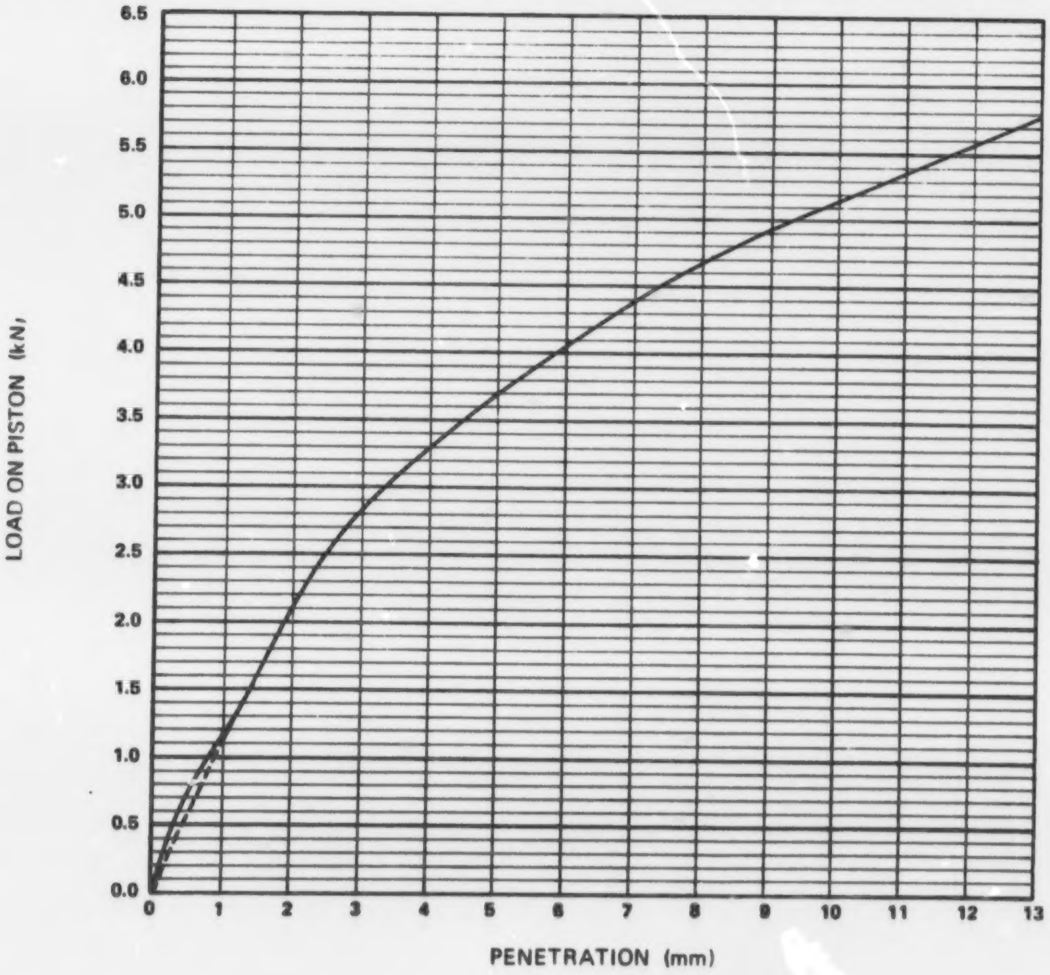
FLYASH %

California Bearing Ratio: 2.5 mm 20 %

CEMENT %

5.0 mm 18 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 100% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 · 00026

Project No.: 314 · 1264.02

Sample: Drumheller

Sand 1% , Silt 30% , Clay 69%

Initial Dry Density: 1245 kg/m^3

Initial Moisture Content: 36.6 %

Stabilizer Dosage: FUJIBETON 8 %

Final Moisture Content: 44.4 %

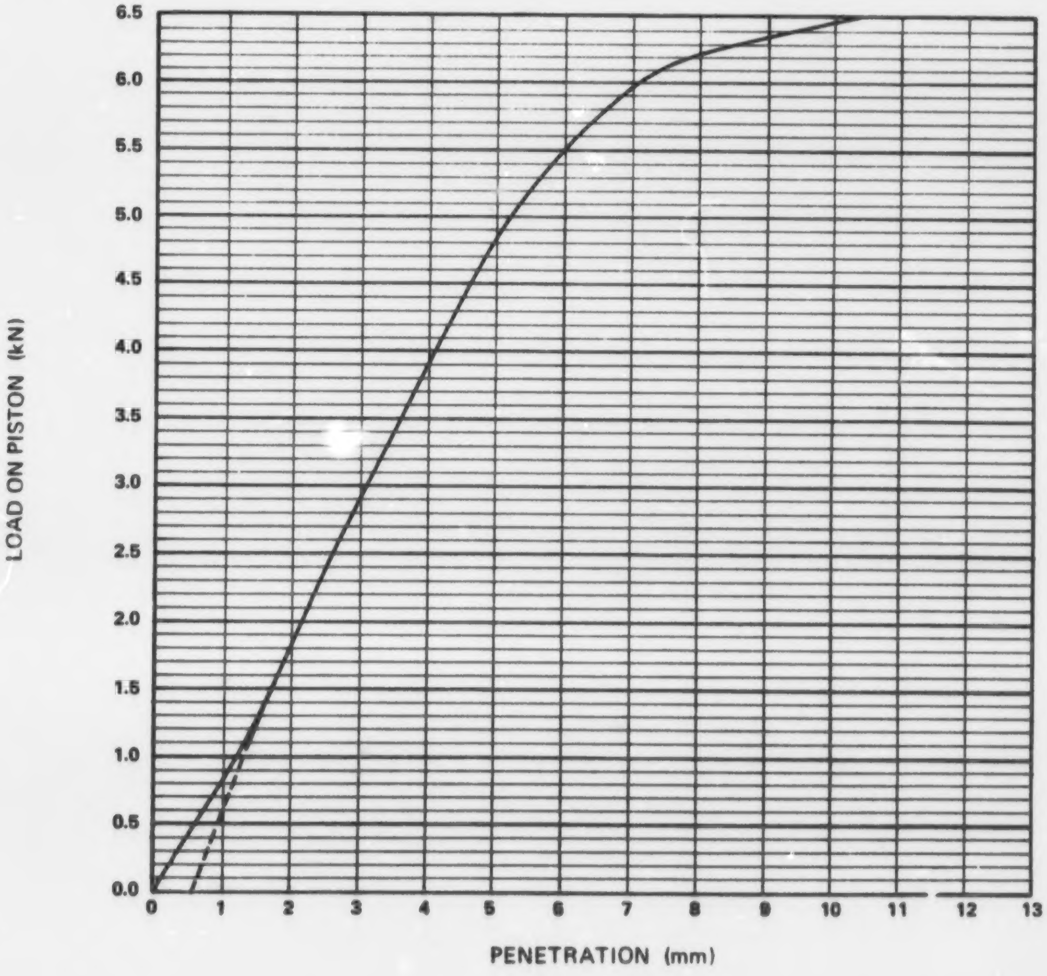
FLYASH %

California Bearing Ratio: 2.5 mm 26 %

CEMENT %

5.0 mm 26 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 75% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Drumheller

Sand 1% , Silt 30% , Clay 69%

Initial Dry Density: 1298 kg/m^3

Initial Moisture Content: 29.2 %

Stabilizer Dosage: FUJIBETON 12 %

Final Moisture Content: 35.8 %

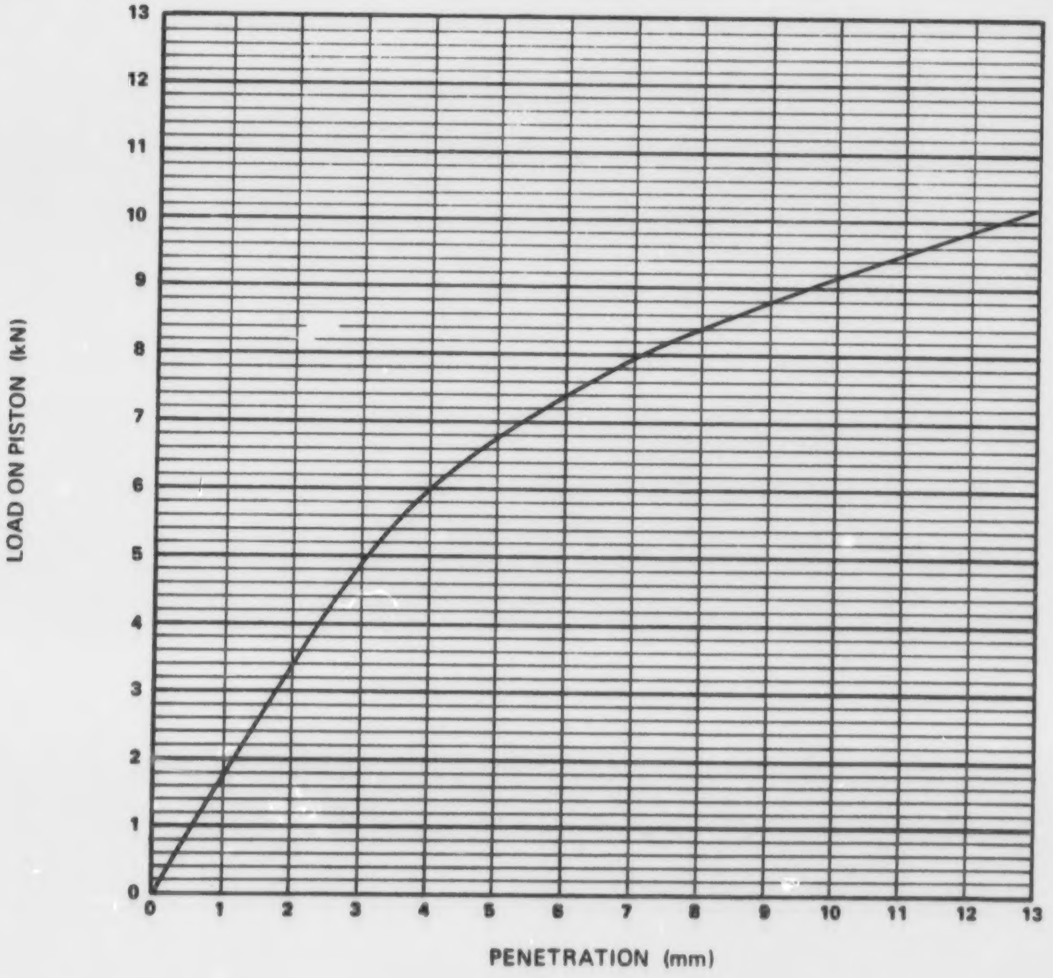
FLYASH %

California Bearing Ratio: 2.5 mm 33 %

CEMENT %

5.0 mm 34 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 100% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Drumheller

Sand 1% , Silt 30% , Clay 69%

Initial Dry Density: 1206 kg/m^3

Initial Moisture Content: 34.7 %

Stabilizer Dosage: FUJIBETON 12 %

Final Moisture Content: 39.4 %

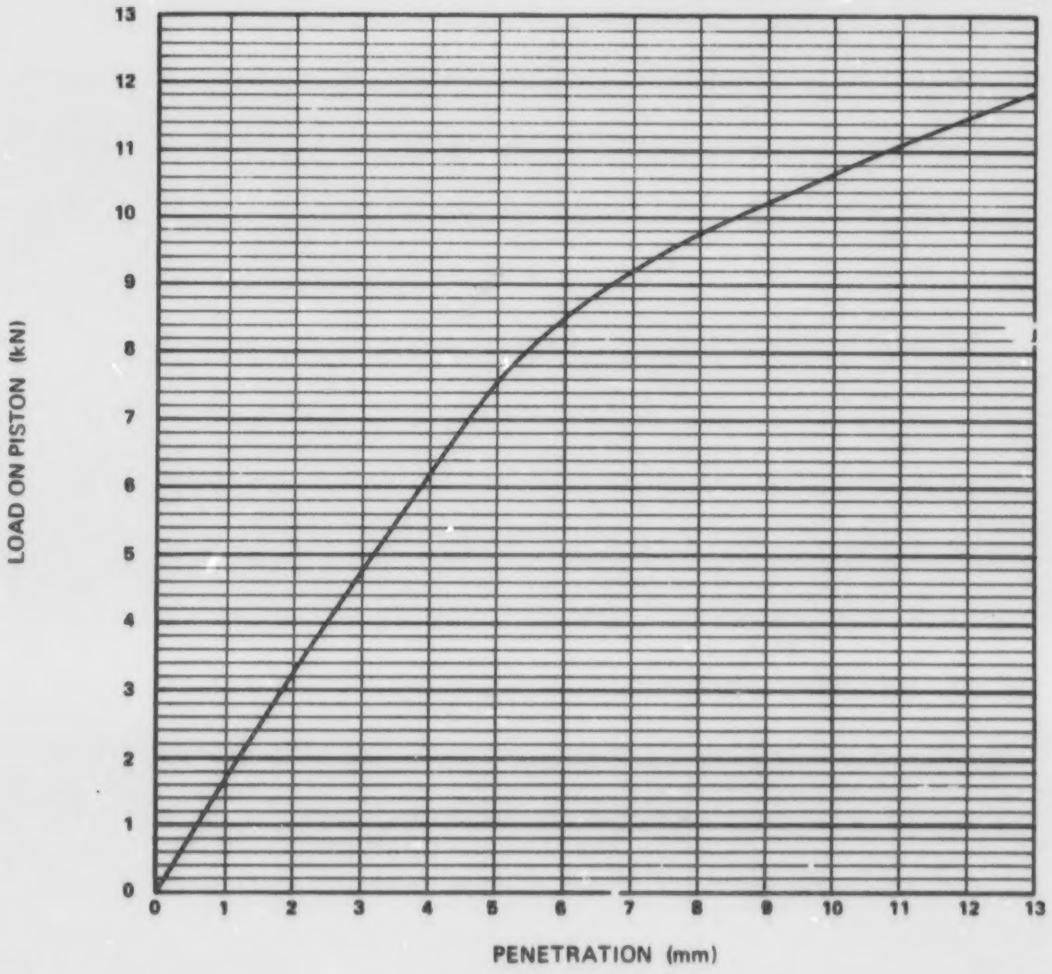
FLYASH %

California Bearing Ratio: 2.5 mm 31 %

CEMENT %

5.0 mm 38 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 75% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Drumheller

Sand 1%, Silt 30%, Clay 69%

Initial Dry Density: 1252 kg/m^3

Initial Moisture Content: 39.1 %

Stabilizer Dosage: FUJIBETON 16 %

Final Moisture Content: 34.2 %

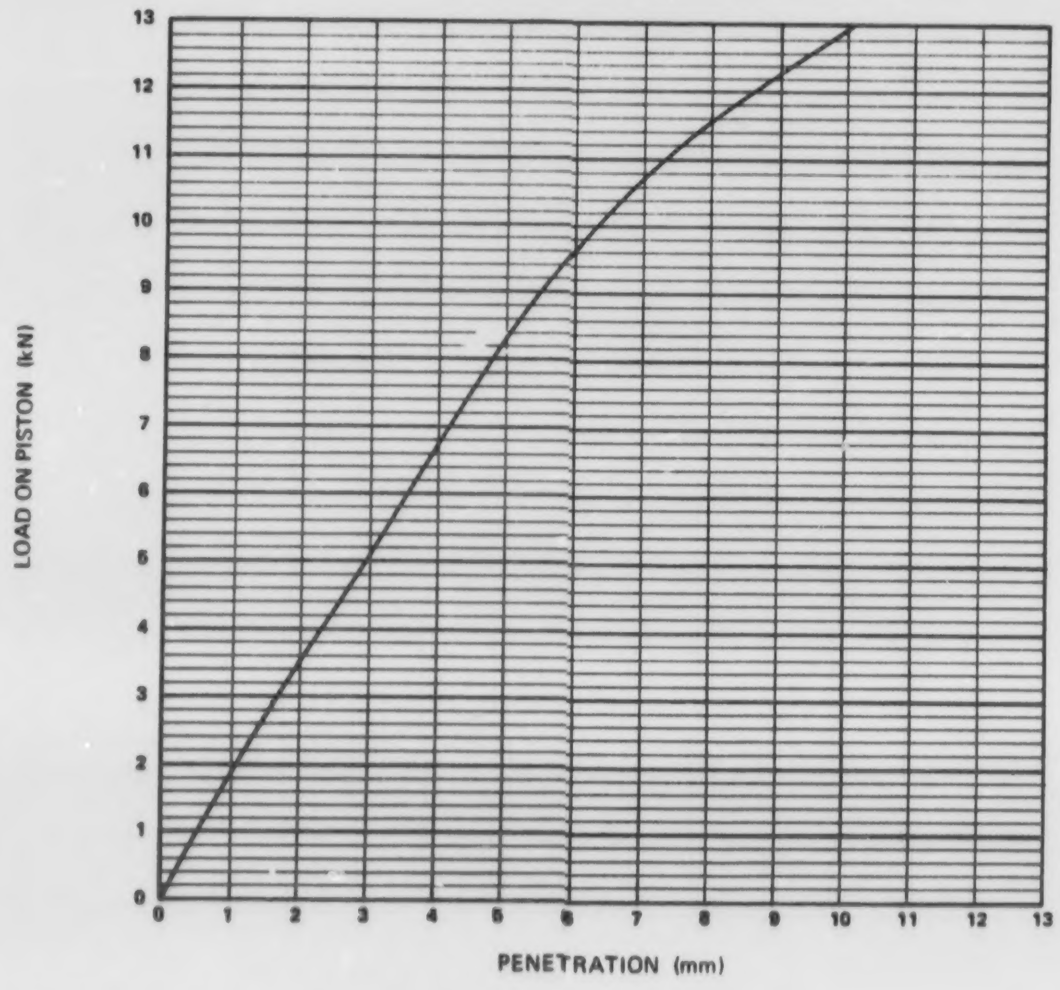
FLYASH %

California Bearing Ratio: 2.5 mm 32 %

CEMENT %

5.0 mm 42 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 100% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Drumheller

Sand 1%, Silt 30%, Clay 69%

Initial Dry Density: 1219 kg/m^3

Initial Moisture Content: 35.4 %

Stabilizer Dosage: FUJIBETON 16 %

Final Moisture Content: 40.7 %

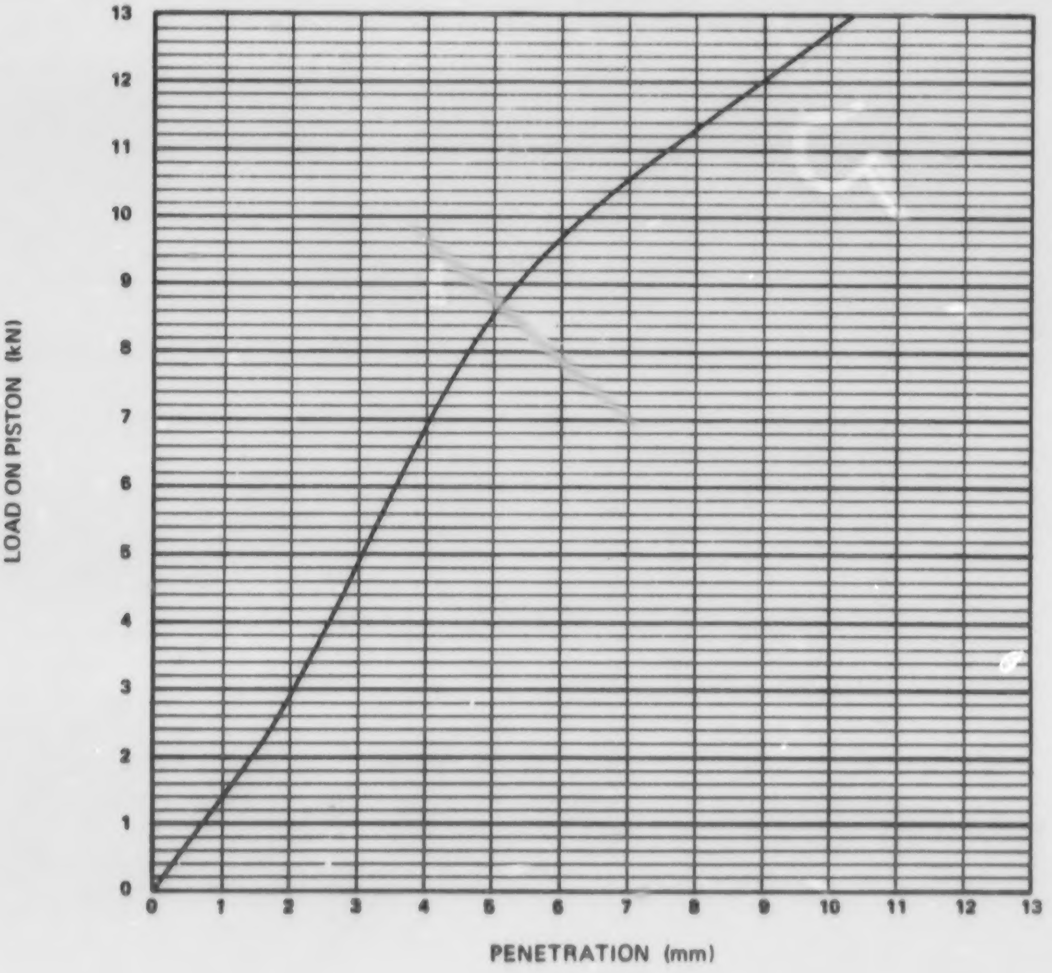
FLYASH %

California Bearing Ratio: 2.5 mm 45 %

CEMENT %

5.0 mm 49 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 75% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Drumheller

Sand 1%, Silt 30%, Clay 69%

Initial Dry Density: 1178 kg/m^3

Initial Moisture Content: 45.4 %

Stabilizer Dosage: FUJIBETON ______ %

Final Moisture Content: 40.0 %

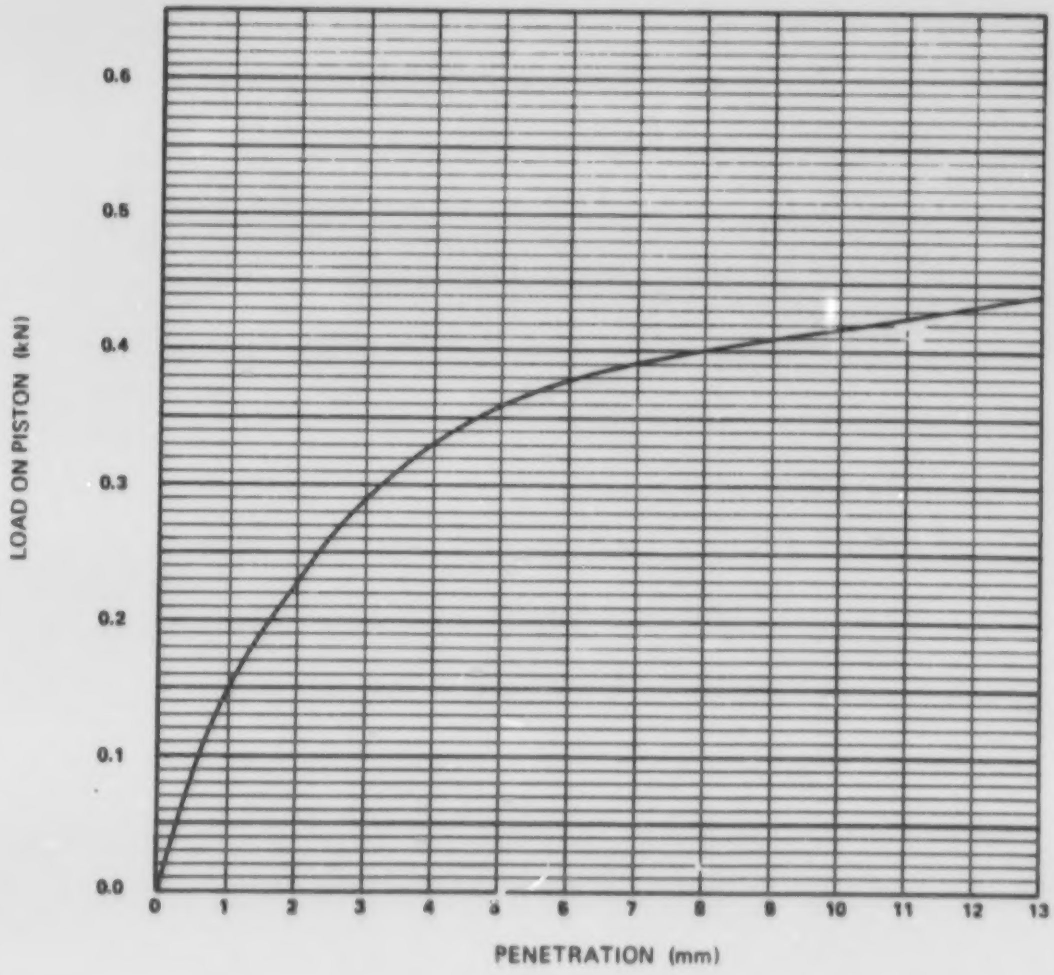
FLYASH 2 %

California Bearing Ratio: 2.5 mm 2.0 %

CEMENT ______ %

5.0 mm 1.8 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 100% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



EBA Engineering Consultants Ltd.

CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Drumheller

Sand 1% , Silt 30% , Clay 69%

Initial Dry Density: 1158 kg/m^3

Initial Moisture Content: 50.3 %

Stabilizer Dosage: FUJIBETON ____ %

Final Moisture Content: 57.0 %

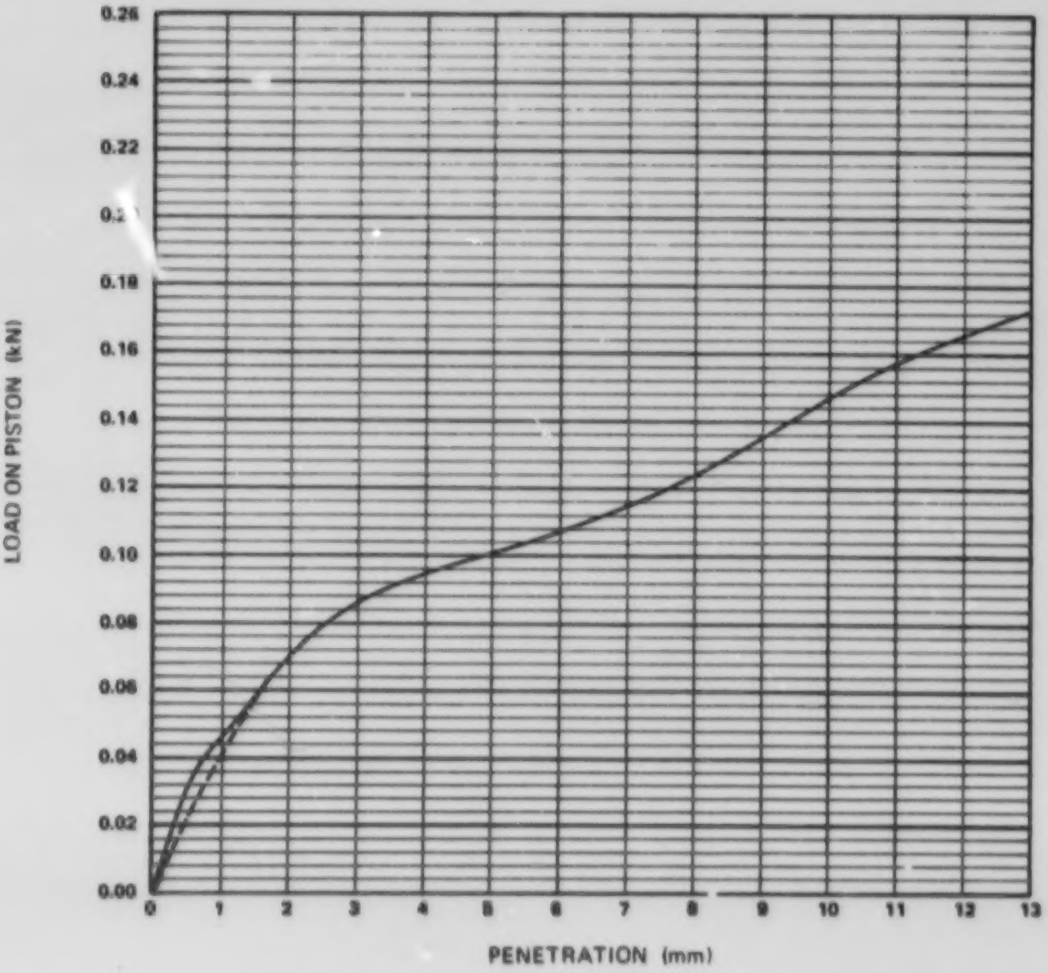
FLYASH 2 %

California Bearing Ratio: 2.5 mm 0.6 %

CEMENT ____ %

5.0 mm 0.5 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 75% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Drumheller

Sand 1%, Silt 30%, Clay 69%

Initial Dry Density: 1152 kg/m^3

Initial Moisture Content: 43.8 %

Stabilizer Dosage: FUJIBETON ______ %

FLYASH 6 %

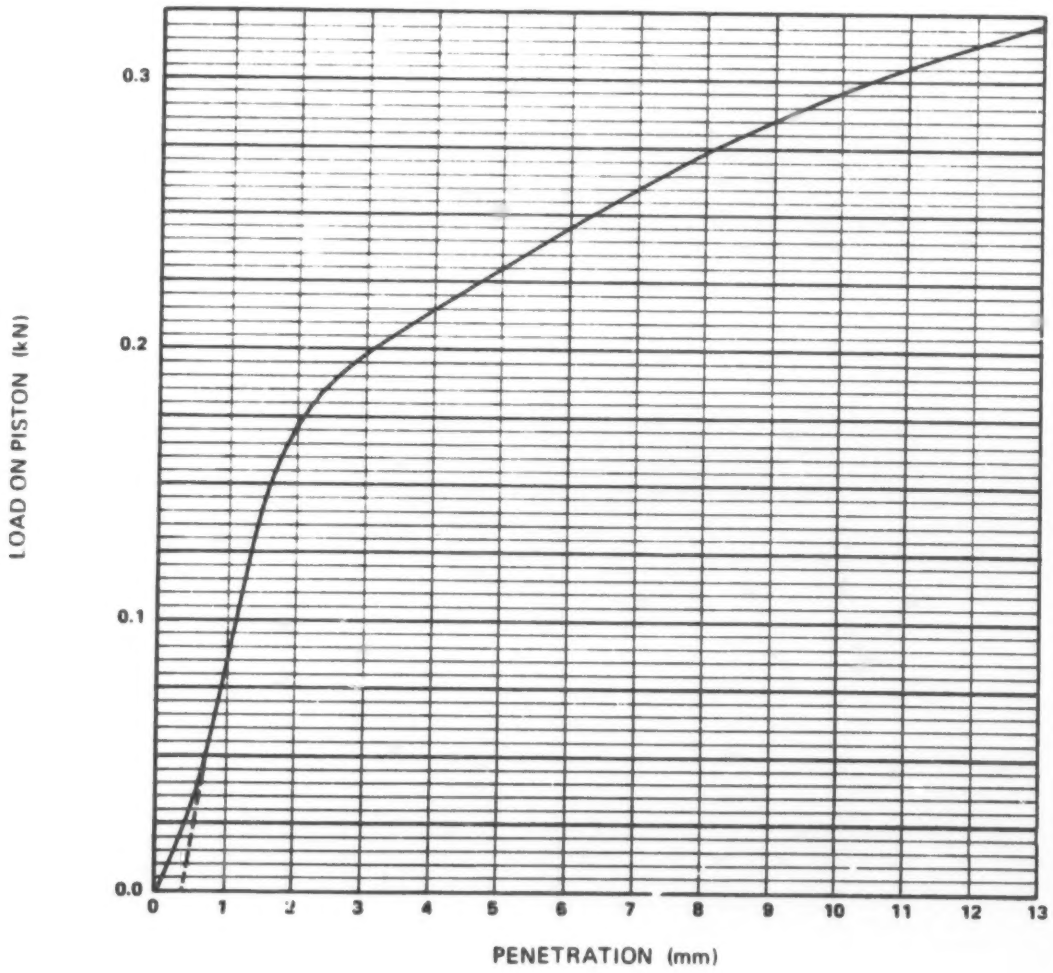
CEMENT ______ %

Final Moisture Content: 45.5 %

California Bearing Ratio: 2.5 mm 1.5 %

5.0 mm 1.2 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 100% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.

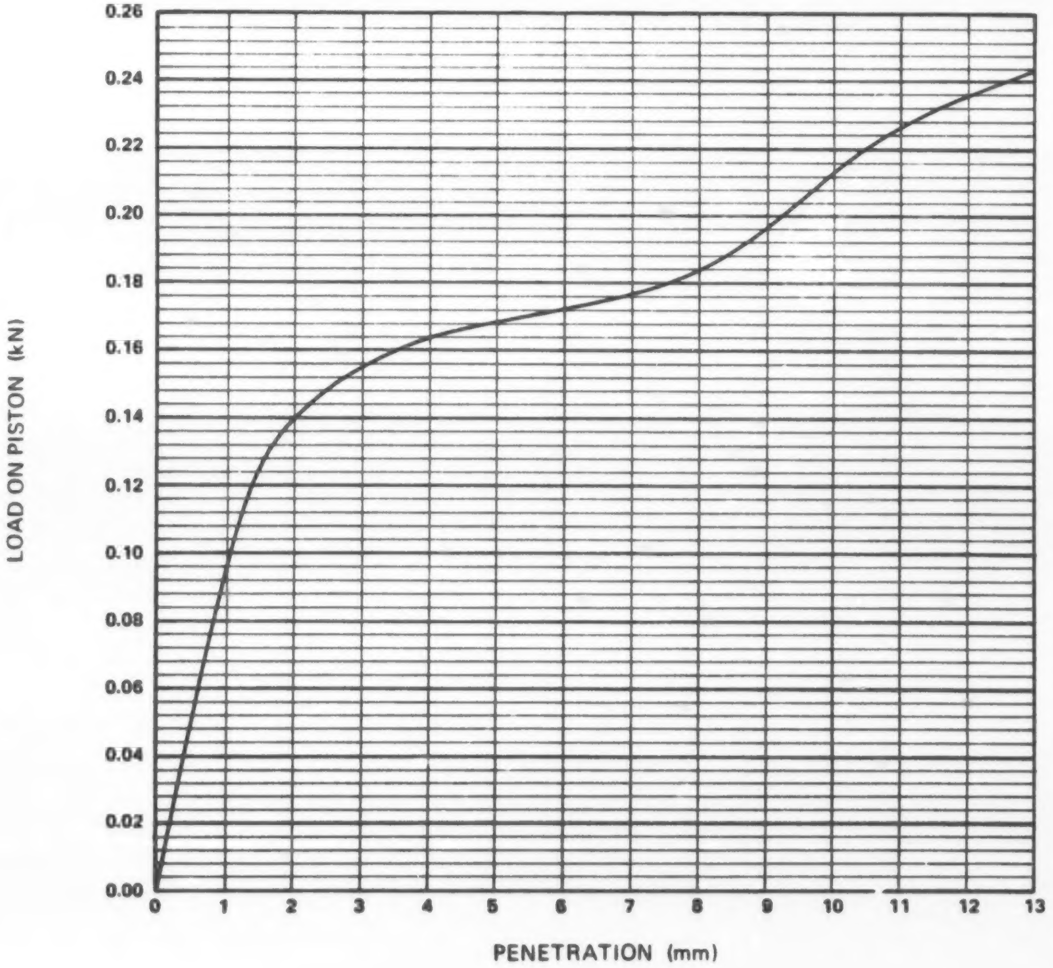


CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client:	TRANSPORT CANADA	Contract No.:	1 SD 83 - 00026
Project No.:	314 - 1264.02		
Sample:	Drumheller	Initial Dry Density:	1215 kg/m^3
	Sand 1%, Silt 30%, Clay 69%	Initial Moisture Content:	41.2 %
Stabilizer Dosage: FUJIBETON	%	Final Moisture Content:	50.2 %
FLYASH	6 %	California Bearing Ratio: 2.5 mm	1.1 %
CEMENT	%	5.0 mm	0.9 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 75% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Drumheller

Sand 1% , Silt 30% , Clay 69%

Initial Dry Density: 1220 kg/m^3

Initial Moisture Content: 39.1 %

Stabilizer Dosage: FUJIBETON %

FLYASH 12 %

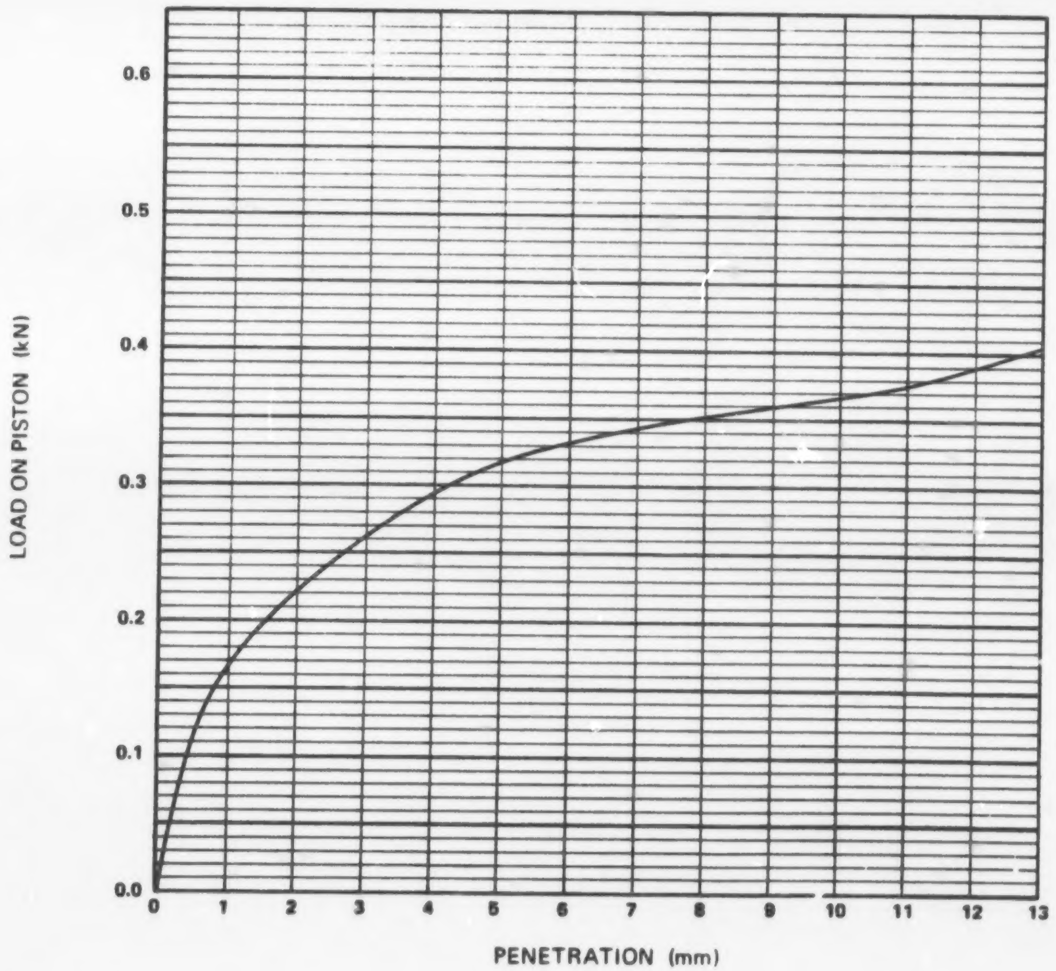
CEMENT %

Final Moisture Content: 42.3 %

California Bearing Ratio: 2.5 mm 1.8 %

5.0 mm 1.6 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 100% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



EBA Engineering Consultants Ltd.

CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Drumheller

Sand 1% , Silt 30% , Clay 69%

Initial Dry Density: 1260 kg/m^3

Initial Moisture Content: 41.4 %

Stabilizer Dosage: FUJIBETON ____ %

FLYASH 12 %

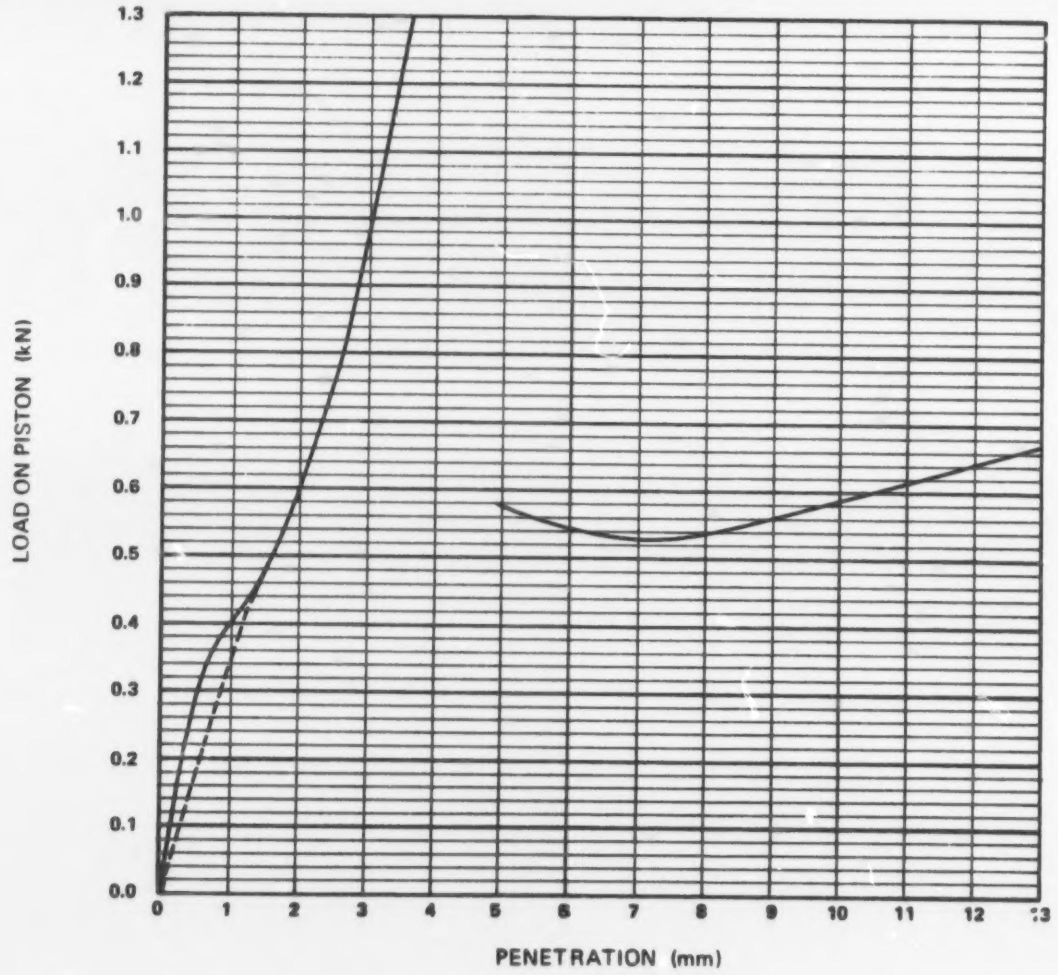
CEMENT ____ %

Final Moisture Content: 43.9 %

California Bearing Ratio: 2.5 mm 5.8 %

5.0 mm ____

Sample statically compacted to maximum dry density obtained during compaction test performed using 75% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 · 00026

Project No.: 314 · 1264.02

Sample: Drumheller

Sand 1%, Silt 30%, Clay 69%

Initial Dry Density: 1247 kg/m^3

Initial Moisture Content: 36.4 %

Stabilizer Dosage: FUJIBETON ____ %

FLYASH 16 %

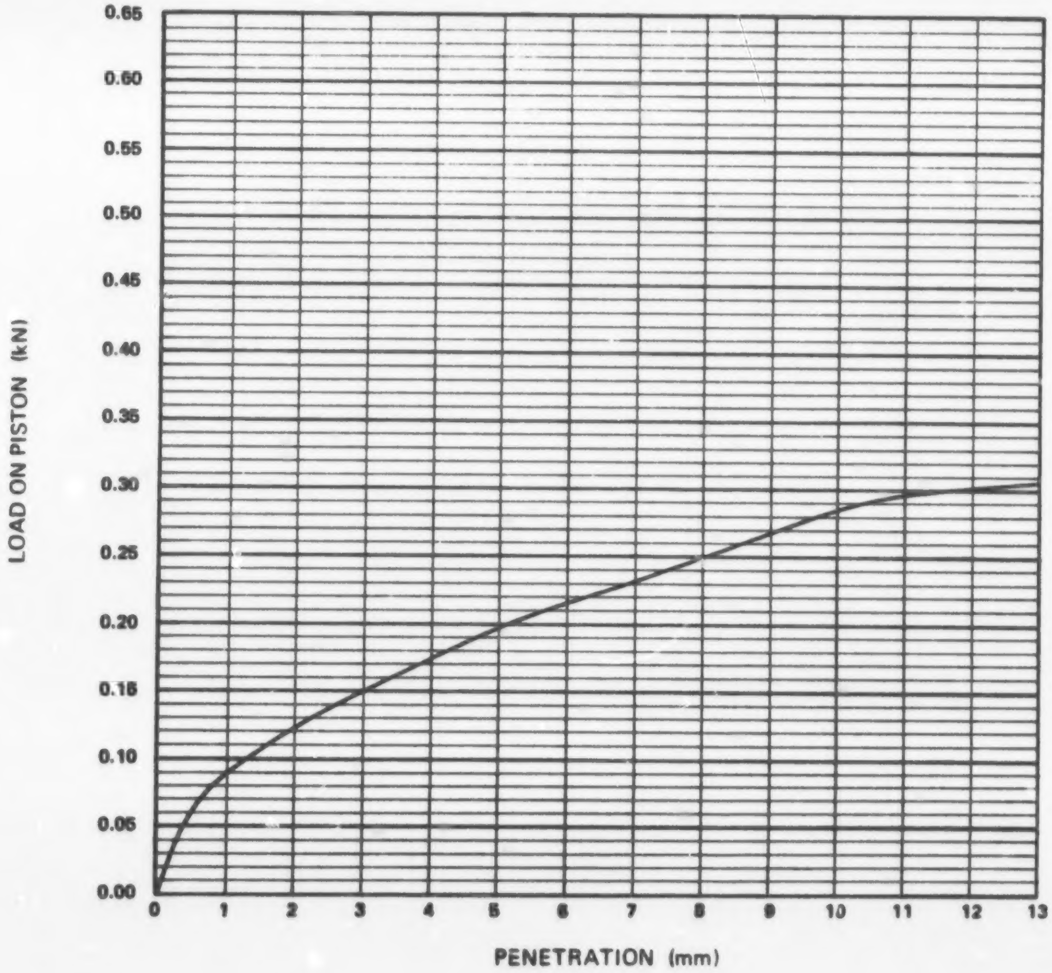
CEMENT ____ %

Final Moisture Content: 50.7 %

California Bearing Ratio: 2.5 mm 1.0 %

5.0 mm 1.0 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 75% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.

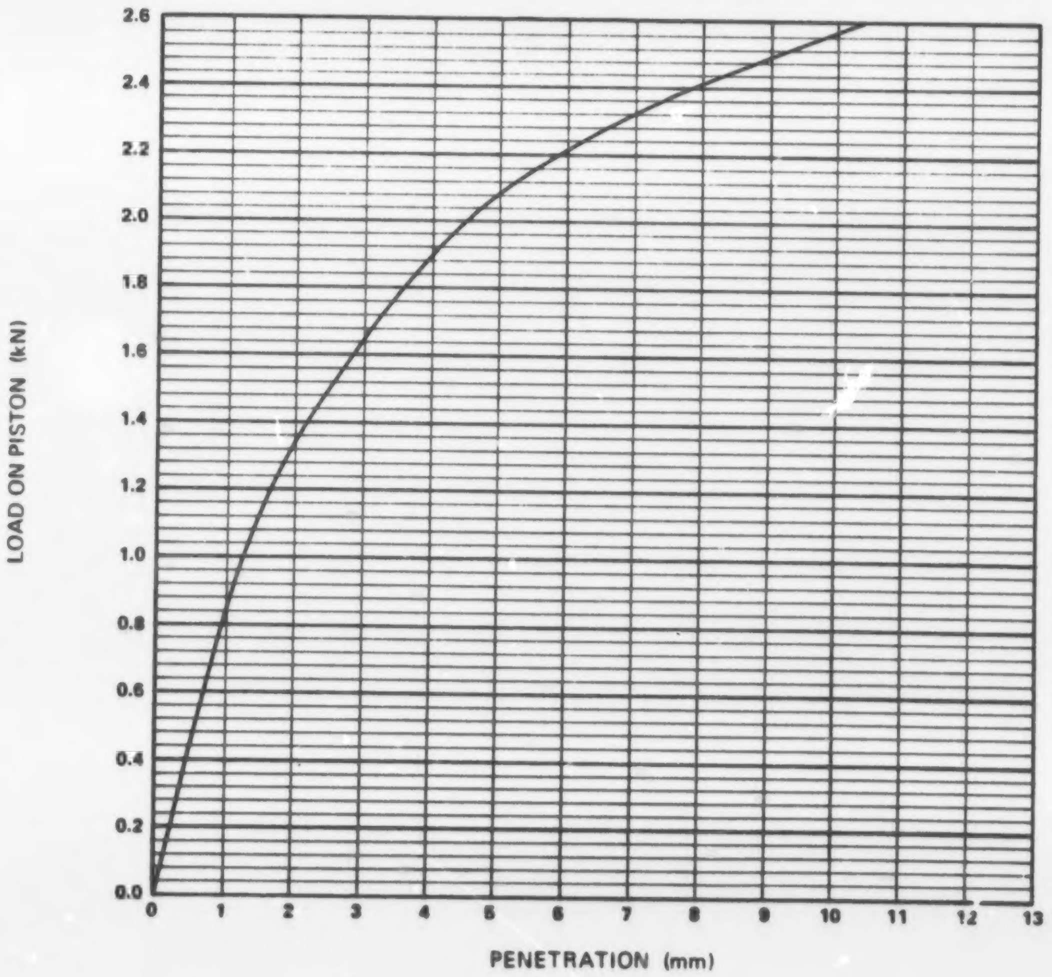


CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA	Contract No.: 1 SD 83 · 00026
Project No.: 314 · 1264.02	
Sample: Drumheller	Initial Dry Density: 1264 kg/m^3
Sand 1%, Silt 30%, Clay 69%	Initial Moisture Content: 38.8 %
Stabilizer Dosage: FUJIBETON ___ %	Final Moisture Content: 35.2 %
FLYASH 9 %	California Bearing Ratio: 2.5 mm 11 %
CEMENT 3 %	5.0 mm 11 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 100% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA
Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

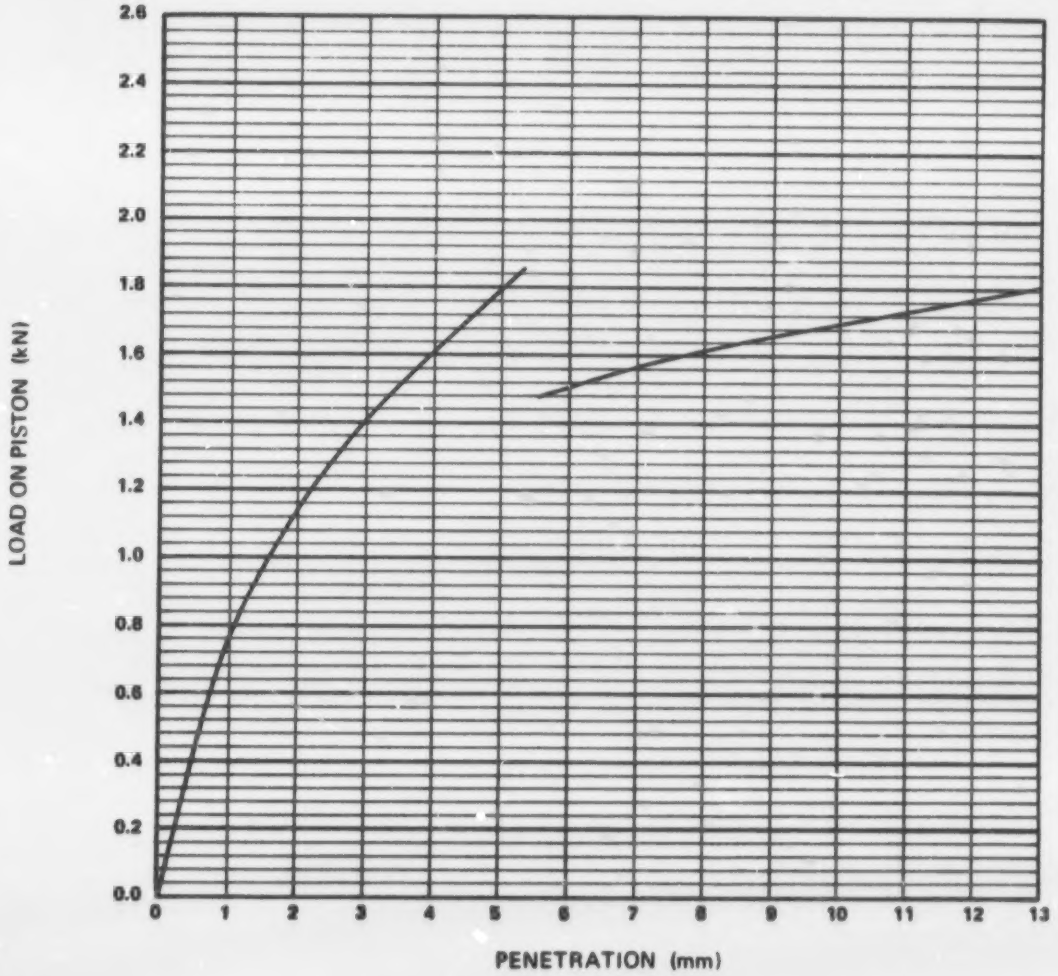
Sample: Drumheller
Sand 1%, Silt 30%, Clay 69%

Initial Dry Density: 1231 kg/m^3
Initial Moisture Content: 41.0 %
Final Moisture Content: 43.6 %

Stabilizer Dosage: FUJIBETON ____ %
FLYASH 9 %
CEMENT 3 %

California Bearing Ratio: 2.5 mm 9.7 %
5.0 mm 9.0 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 75% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1270 kg/m3

Sample: Drumheller

Sand 1 %, Silt 30 %, Clay 69 %

Design Optimum Moisture Content %: 30 %

Initial Dry Density: 1184 kg/m3

Initial Moisture Content: 32.0 %

Initial Volume: 934.1 cm3

Stabilizer Dosage: FUJIBETON 2 %

Volume After Curing: 949.5 cm3

FLYASH %

Final Moisture Content: --- %

CEMENT %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 559 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm^3)	VOLUME AFTER DRYING AND BRUSHING (cm^3)	WEIGHT AFTER DRYING AND BRUSHING (g)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during first immersion.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1295 kg/m³

Sample: Drumheller

Design Optimum Moisture Content:% 32.0 %

Sand 1 % , Silt 30 % , Clay 69 %

Initial Dry Density: 1293 kg/m³

Initial Moisture Content: 27.1 %

Initial Volume: 933.3 cm³

Stabilizer Dosage: FUJIBETON 2 %

Volume After Curing: --- cm³

FLYASH %

Final Moisture Content: 54.2 %

CEMENT %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 559 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm³)	VOLUME AFTER DRYING AND BRUSHING (cm³)	WEIGHT AFTER DRYING AND BRUSHING (g)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during initial curing period.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 · 00026

Project No.: 314 · 1264.02

Design Maximum Dry Density: 1400 kg/m³

Sample: Drumheller

Design Optimum Moisture Content:% 23 %

Sand 1 %, Silt 30 %, Clay 69 %

Initial Dry Density: 1277 kg/m³

Initial Moisture Content: 26.1 %

Initial Volume: 907.4 cm³

Stabilizer Dosage: FUJIBETON 5 %

Volume After Curing: 932.6 cm³

FLYASH %

Final Moisture Content: --- %

CEMENT %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 559 · 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm³)	VOLUME AFTER DRYING AND BRUSHING (cm³)	WEIGHT AFTER DRYING AND BRUSHING (g)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during first immersion.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 · 00026

Project No.: 314 · 1264.02

Design Maximum Dry Density: 1300 kg/m³

Sample: Drumheller

Design Optimum Moisture Content:% 30 %

Sand 1 %, Silt 30 %, Clay 69 %

Initial Dry Density: 1308 kg/m³

Initial Moisture Content: 19.4 %

Initial Volume: 950.1 cm³

Stabilizer Dosage FUJIBETON 5 %

Volume After Curing: --- cm³

FLYASH %

Final Moisture Content: 57.4 %

CEMENT %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 559 · 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm³)	VOLUME AFTER DRYING AND BRUSHING (cm³)	WEIGHT AFTER DRYING AND BRUSHING (g)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during initial curing period.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 1264.02

Design Maximum Dry Density: 1280 kg/m³

Sample: Drumheller

Design Optimum Moisture Content:% 33 %

Sand 1 %, Silt 30 %, Clay 69 %

Initial Dry Density: 1206 kg/m³

Initial Moisture Content: 33.4 %

Initial Volume: 900.4 cm³

Stabilizer Dosage: FUJIBETON 8 %

Volume After Curing: 927.8 cm³

FLYASH %

Final Moisture Content: --- %

CEMENT %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 559 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm³)	VOLUME AFTER DRYING AND BRUSHING (cm³)	WEIGHT AFTER DRYING AND BRUSHING (g)
1	937.2	546.6	790.0
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during second immersion.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 00026

Project No.: 314 - 1264 02

Design Maximum Dry Density: 1340 kg m³

Sample: Drumheller

Design Optimum Moisture Content %: 27.0 %

Sand 1 %, Silt 30 %, Clay 69 %

Initial Dry Density: 1340 kg m³

Initial Moisture Content: 27.0 %

Initial Volume: 937.0 cm³

Stabilizer Dosage: FUJIBETON 8 %

Volume After Curing: 1105.0 cm³

FLYASH %

Final Moisture Content: 48.8 %

CEMENT %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 559 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA

CYCLE	VOLUME AFTER SOAKING (cm³)	VOLUME AFTER DRYING AND BRUSHING (cm³)	WEIGHT AFTER DRYING AND BRUSHING (g)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during initial curing period.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1375 kg/m³

Sample: Drumheller

Design Optimum Moisture Content:% 22 %

Sand 1 %, Silt 30 %, Clay 69 %

Initial Dry Density: 1269 kg/m³

Initial Moisture Content: 25.1 %

Initial Volume: 953.6 cm³

Stabilizer Dosage FUJIBETON 12 %

Volume After Curing: --- cm³

FLYASH %

Final Moisture Content: --- %

CEMENT %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 559 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm³)	VOLUME AFTER DRYING AND BRUSHING (cm³)	WEIGHT AFTER DRYING AND BRUSHING (g)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during initial curing period.

EBA Engineering Consultants Ltd.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 · 00026

Project No.: 314 · 1264.02

Design Maximum Dry Density: 1340 kg/m^3

Sample: Drumheller

Design Optimum Moisture Content:% 25.0 %

Sand 1 %, Silt 30 %, Clay 69 %

Initial Dry Density: 1308 kg/m^3

Initial Moisture Content: 19.8 %

Initial Volume: 936.2 cm^3

Stabilizer Dosage: FUJIBETON 12 %

Volume After Curing: --- cm^3

FLYASH %

Final Moisture Content: 44.7 %

CEMENT %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 559 · 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm^3)	VOLUME AFTER DRYING AND BRUSHING (cm^3)	WEIGHT AFTER DRYING AND BRUSHING (g)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during initial curing period.

EBA Engineering Consultants Ltd.

eba

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1340 kg/m3

Sample: Drumheller

Design Optimum Moisture Content:% 30.0 %

Sand 1 %, Silt 30 %, Clay 69 %

Initial Dry Density: 1238 kg/m3

Initial Moisture Content: 32.5 %

Initial Volume: 955.2 cm3

Stabilizer Dosage: FUJIBETON 16 %

Volume After Curing: 934.6 cm3

FLYASH %

Final Moisture Content: 36.5 %

CEMENT %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 559 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm3)	VOLUME AFTER DRYING AND BRUSHING (cm3)	WEIGHT AFTER DRYING AND BRUSHING (g)
1	942.6	533.7	857.6
2	548.1	532.7	800.8
3	544.8	534.6	724.7
4			
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during fourth immersion.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Project No.: 314 - 1264.02

Sample: Drumheller

Sand 1 %, Silt 30 %, Clay 69 %

Stabilizer Dosage: FUJIBETON 16 %

FLYASH %

CEMENT %

Cont[illegible]: 1 SD 83 - 00026

Des[illegible]ximum Dry Density: 1340 kg/m³

Design Optimum Moisture Content:% 27 %

Initial Dry Density: 1316 kg/m³

Initial Moisture Content: 25.3 %

Initial Volume: 944.7 cm³

Volume After Curing: --- cm³

Final Moisture Content: 40.6 %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 559 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm³)	VOLUME AFTER DRYING AND BRUSHING (cm³)	WEIGHT AFTER DRYING AND BRUSHING (g)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during initial curing period.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client:	TRANSPORT CANADA	Contract No.:	1 SD 83 - 00026
Project No.:	314 - 1264.02	Design Maximum Dry Density:	1278 kg/m³
Sample:	Drumheller	Design Optimum Moisture Content:%	34 %
	Sand 1 %, Silt 30 %, Clay 69 %	Initial Dry Density:	1192 kg/m³
		Initial Moisture Content:	35.7 %
		Initial Volume:	926.1 cm³
Stabilizer Dosage: FUJIBETON	%	Volume After Curing:	--- cm³
FLYASH	2 %	Final Moisture Content:	--- %
CEMENT	%	Stabilized Soil Loss:	100 %

Method of Sample Preparation: ASTM D 559 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm³)	VOLUME AFTER DRYING AND BRUSHING (cm³)	WEIGHT AFTER DRYING AND BRUSHING (g)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during initial curing.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1280 kg/m³

Sample: Drumheller

Design Optimum Moisture Content:% 36.0 %

Sand 1 %, Silt 30 %, Clay 69 %

Initial Dry Density: 1312 kg/m³

Initial Moisture Content: 31.7 %

Initial Volume: 935.5 cm³

Stabilizer Dosage: FUJIBETON ____ %

Volume After Curing: --- cm³

FLYASH 2 %

Final Moisture Content: 60.7 %

CEMENT ____ %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 559 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm³)	VOLUME AFTER DRYING AND BRUSHING (cm³)	WEIGHT AFTER DRYING AND BRUSHING (g)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during initial curing period.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1246 kg/m³

Sample: Drumheller

Design Optimum Moisture Content:% 33.3 %

Sand 1 %, Silt 30 %, Clay 69 %

Initial Dry Density: 1181 kg/m³

Initial Moisture Content: 32.9 %

Initial Volume: 885.1 cm³

Stabilizer Dosage: FUJIBETON ______ %

Volume After Curing: 931.3 cm³

FLYASH 6 %

Final Moisture Content: --- %

CEMENT ______ %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 559 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm³)	VOLUME AFTER DRYING AND BRUSHING (cm³)	WEIGHT AFTER DRYING AND BRUSHING (g)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during initial immersion.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1320 kg/m^3

Sample: Drumheller

Design Optimum Moisture Content:% 30.0 %

Sand 1 %, Silt 30 %, Clay 69 %

Initial Dry Density: 1305 kg/m^3

Initial Moisture Content: 30.7 %

Initial Volume: 945.9 cm^3

Stabilizer Dosage: FUJIBETON %

Volume After Curing: --- cm^3

FLYASH 6 %

Final Moisture Content: 65.4 %

CEMENT %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 559 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm^3)	VOLUME AFTER DRYING AND BRUSHING (cm^3)	WEIGHT AFTER DRYING AND BRUSHING (g)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during initial curing period.

EBA Engineering Consultants Ltd.

eba

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Project No.: 314 - 1264.02

Sample: Drumheller

Sand 1 %, Silt 30 %, Clay 69 %

Stabilizer Dosage: FUJIBETON ____ %

FLYASH 12 %

CEMENT ____ %

Contract No.: 1 SD 83 - 00026

Design Maximum Dry Density: 1305 kg/m³

Design Optimum Moisture Content:% 30.0 %

Initial Dry Density: 1234 kg/m³

Initial Moisture Content: 29.8 %

Initial Volume: 926.1 cm³

Volume After Curing: 928.5 cm³

Final Moisture Content: --- %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 559 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm^3)	VOLUME AFTER DRYING AND BRUSHING (cm^3)	WEIGHT AFTER DRYING AND BRUSHING (g)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during initial immersion.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1360 kg/m3

Sample: Drumheller

Design Optimum Moisture Content:% 31.0 %

Sand 1 %, Silt 30 %, Clay 69 %

Initial Dry Density: 1250 kg/m3

Initial Moisture Content: 26.5 %

Initial Volume: 923.1 cm3

Stabilizer Dosage: FUJIBETON ____ %

Volume After Curing: --- cm3

FLYASH 12 %

Final Moisture Content: 58.1 %

CEMENT ____ %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 559 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm3)	VOLUME AFTER DRYING AND BRUSHING (cm3)	WEIGHT AFTER DRYING AND BRUSHING (g)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during initial curing period.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client:	TRANSPORT CANADA	Contract No.:	1 SD 83 - 00026
Project No.:	314 - 1264.02	Design Maximum Dry Density:	1315 kg/m3
Sample:	Drumheller	Design Optimum Moisture Content:%:	30.0 %
	Sand 1 %, Silt 30 %, Clay 69 %	Initial Dry Density:	1219 kg/m3
		Initial Moisture Content:	31.9 %
		Initial Volume:	917.5 cm3
Stabilizer Dosage: FUJIBETON	%	Volume After Curing:	938.0 cm3
FLYASH	16 %	Final Moisture Content:	--- %
CEMENT	%	Stabilized Soil Loss:	100 %

Method of Sample Preparation: ASTM D 559 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm3)	VOLUME AFTER DRYING AND BRUSHING (cm3)	WEIGHT AFTER DRYING AND BRUSHING (g)
1	577.2	---	---
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during initial drying period.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client:	TRANSPORT CANADA	Contract No.:	1 SD 83 - 00026
Project No.:	314 - 1264.02	Design Maximum Dry Density:	1350 kg/m^3
Sample:	Drumheller	Design Optimum Moisture Content:%	26.0 %
	Sand 1 %, Silt 30 %, Clay 69 %	Initial Dry Density:	1245 kg/m^3
		Initial Moisture Content:	30.3 %
		Initial Volume:	940.0 cm^3
Stabilizer Dosage: FUJIBETON	%	Volume After Curing:	--- cm^3
FLYASH	16 %	Final Moisture Content:	55.4 %
CEMENT	%	Stabilized Soil Loss:	100 %

Method of Sample Preparation: ASTM D 559 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm^3)	VOLUME AFTER DRYING AND BRUSHING (cm^3)	WEIGHT AFTER DRYING AND BRUSHING (g)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during initial curing period.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1350 kg/m^3

Sample: Drumheller

Design Optimum Moisture Content: % 30 %

Sand 1 %, Silt 30 %, Clay 69 %

Initial Dry Density: 1258 kg/m^3

Initial Moisture Content: 32.0 %

Initial Volume: 926.4 cm^3

Stabilizer Dosage: FUJIBETON %

FLYASH 9 %

CEMENT 3 %

Volume After Curing: --- cm^3

Final Moisture Content: --- %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 559 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm^3)	VOLUME AFTER DRYING AND BRUSHING (cm^3)	WEIGHT AFTER DRYING AND BRUSHING (g)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during initial curing period.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1335 kg/m^3

Sample: Drumheller

Sand 1 %, Silt 30 %, Clay 69 %

Design Optimum Moisture Content %: 30.0 %

Initial Dry Density: 1300 kg/m^3

Initial Moisture Content: 29.3 %

Initial Volume: 945.3 cm^3

Stabilizer Dosage: FUJIBETON ______ %

Volume After Curing: --- cm^3

FLYASH 9 %

Final Moisture Content: 51.3 %

CEMENT 3 %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 559 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA

CYCLE	VOLUME AFTER SOAKING (cm^3)	VOLUME AFTER DRYING AND BRUSHING (cm^3)	WEIGHT AFTER DRYING AND BRUSHING (g)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during initial curing period.

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1270 kg/m³

Sample: Drumheller

Sand 1 %, Silt 30 %, Clay 69 %

Design Optimum Moisture Content: 30.0 %

Initial Dry Density: 1195 kg/m³

Initial Moisture Content: 30.8 %

Initial Volume: 934.2 cm³

Stabilizer Dosage: FUJIBETON 2 %

FLYASH %

CEMENT %

Volume After Curing: --- cm³

Final Moisture Content: 40.2 %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 560 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm³)	WEIGHT AFTER THAWING AND BRUSHING (g)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated during initial curing period

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client:	TRANSPORT CANADA	Contract No.:	1 SD 83 - 00026
Project No.:	314 - 1264.02	Design Maximum Dry Density:	1295 kg/m³
Sample:	Drumheller	Design Optimum Moisture Content:	32.0 %
	Sand 1 %, Silt 30 %, Clay 69 %	Initial Dry Density:	1296 kg/m³
		Initial Moisture Content:	27.1 %
		Initial Volume:	916.1 cm³
Stabilizer Dosage:	FUJIBETON 2 %	Volume After Curing:	--- cm³
	FLYASH %	Final Moisture Content:	52.8 %
	CEMENT %	Stabilized Soil Loss:	100 %

Method of Sample Preparation: ASTM D 560 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm³)	WEIGHT AFTER THAWING AND BRUSHING (g)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated during initial curing period

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1400 kg/m³

Sample: Drumheller

Sand 1 %, Silt 30 %, Clay 69 %

Design Optimum Moisture Content: 23.0 %

Initial Dry Density: 1326 kg/m³

Initial Moisture Content: 22.9 %

Initial Volume: 889.0 cm³

Stabilizer Dosage: FUJIBETON 5 %

Volume After Curing: --- cm³

FLYASH ____ %

Final Moisture Content: 24.6 %

CEMENT ____ %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 560 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm³)	WEIGHT AFTER THAWING AND BRUSHING (g)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated during initial curing period

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1300 kg/m³

Sample: Drumheller

Sand 1 %, Silt 30 %, Clay 69 %

Design Optimum Moisture Content: 30.0 %

Initial Dry Density: 1311 kg/m³

Initial Moisture Content: 20.6 %

Initial Volume: 951.7 cm³

Stabilizer Dosage: FUJIBETON 5 %

FLYASH %

CEMENT %

Volume After Curing: --- cm³

Final Moisture Content: 50.2 %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 560 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm³)	WEIGHT AFTER THAWING AND BRUSHING (g)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated during initial curing period

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1280 kg/m3

Sample: Drumheller

Sand 1 %, Silt 30 %, Clay 69 %

Design Optimum Moisture Content: 33.0 %

Initial Dry Density: 1214 kg/m3

Initial Moisture Content: 32.8 %

Initial Volume: 892.0 cm3

Stabilizer Dosage: FUJIBETON 8 %

FLYASH %

CEMENT %

Volume After Curing: --- cm3

Final Moisture Content: 35.0 %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 560 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm3)	WEIGHT AFTER THAWING AND BRUSHING (g)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated during initial curing period

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA	Contract No.: 1 SD 83 - 00026
Project No.: 314 - 1264.02	Design Maximum Dry Density: 1340 kg/m³
Sample: Drumheller	Design Optimum Moisture Content: 27.0 %
Sand 1 %, Silt 30 %, Clay 69 %	Initial Dry Density: 1258 kg/m³
	Initial Moisture Content: 30.7 %
	Initial Volume: 951.4 cm³
Stabilizer Dosage: FUJIBETON 8 %	Volume After Curing: --- cm³
FLYASH %	Final Moisture Content: 46.0 %
CEMENT %	Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 560 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm³)	WEIGHT AFTER THAWING AND BRUSHING (g)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated during initial curing period

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA	Contract No.: 1 SD 83 - 00026
Project No.: 314 - 1264.02	Design Maximum Dry Density: 1375 kg/m³
Sample: Drumheller	Design Optimum Moisture Content: 22.0 %
Sand 1 %, Silt 30 %, Clay 69 %	Initial Dry Density: 1243 kg/m³
	Initial Moisture Content: 27.8 %
	Initial Volume: 950.7 cm³
Stabilizer Dosage: FUJIBETON 12 %	Volume After Curing: --- cm³
FLYASH %	Final Moisture Content: 33.6 %
CEMENT %	Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 560 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm³)	WEIGHT AFTER THAWING AND BRUSHING (g)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated during initial curing period

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1340 kg/m³

Sample: Drumheller

Design Optimum Moisture Content: 25.0 %

Sand 1 %, Silt 30 %, Clay 69 %

Initial Dry Density: 1346 kg/m³

Initial Moisture Content: 19.5 %

Initial Volume: 948.6 cm³

Stabilizer Dosage: FUJIBETON 12 %

Volume After Curing: --- cm³

FLYASH %

Final Moisture Content: 48.8 %

CEMENT %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 560 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm³)	WEIGHT AFTER THAWING AND BRUSHING (g)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated during initial curing period

EBA Engineering Consultants Ltd.

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1340 kg/m3

Sample: Drumheller

Design Optimum Moisture Content: 30.0 %

Sand 1 %, Silt 30 %, Clay 69 %

Initial Dry Density: 1264 kg/m3

Initial Moisture Content: 30.4 %

Initial Volume: 952.3 cm3

Stabilizer Dosage: FUJIBETON 16 %

Volume After Curing: --- cm3

FLYASH %

Final Moisture Content: 33 %

CEMENT %

Stabilized Soil Loss: 47 %

Method of Sample Preparation: ASTM D 560 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm3)	WEIGHT AFTER THAWING AND BRUSHING (g)
1	610.1	1039.8
2	613.4	1022.2
3	597.5	1011.7
4	613.8	973.9
5	599.2	920.7
6	569.1	913.6
7	578.2	882.1
8	546.4	879.3
9	589.1	861.6
10	579.6	851.0
11	506.0	846.4
12	546.7	833.9

Remarks: Unconfined compressive strength after durability test determined as 0.32 MPa

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1340 kg/m³

Sample: Drumheller

Design Optimum Moisture Content: 27.0 %

Sand 1 %, Silt 30 %, Clay 69 %

Initial Dry Density: 1283 kg/m³

Initial Moisture Content: 26.2 %

Initial Volume: 946.4 cm³

Stabilizer Dosage: FUJIBETON 16 %

Volume After Curing: --- cm³

FLYASH %

Final Moisture Content: 42.1 %

CEMENT %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 560 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm³)	WEIGHT AFTER THAWING AND BRUSHING (g)
1	1129.4	1713.9
2	782.2	1349.1
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated during third thawing period

EBA Engineering Consultants Ltd.

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1278 kg/m3

Sample: Drumheller

Sand 1 %, Silt 30 %, Clay 69 %

Design Optimum Moisture Content: 34.0 %

Initial Dry Density: 1174 kg/m3

Initial Moisture Content: 38.1 %

Initial Volume: 901.7 cm3

Stabilizer Dosage: FUJIBETON %

FLYASH 2 %

CEMENT %

Volume After Curing: --- cm3

Final Moisture Content: 37.4 %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 560 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm3)	WEIGHT AFTER THAWING AND BRUSHING (g)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated during initial curing period

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client:	TRANSPORT CANADA	Contract No.:	1 SD 83 - 00026
Project No.:	314 - 1264.02	Design Maximum Dry Density:	1280 kg/m³
Sample:	Drumheller	Design Optimum Moisture Content:	36.0 %
	Sand 1 %, Silt 30 %, Clay 69 %	Initial Dry Density:	1229 kg/m³
		Initial Moisture Content:	34.7 %
		Initial Volume:	934.7 cm³
Stabilizer Dosage: FUJIBETON	%	Volume After Curing:	--- cm³
FLYASH	2 %	Final Moisture Content:	53.0 %
CEMENT	%	Stabilized Soil Loss:	100 %

Method of Sample Preparation: ASTM D 560 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm³)	WEIGHT AFTER THAWING AND BRUSHING (g)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated during initial curing period

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1246 kg/m3

Sample: Drumheller

Design Optimum Moisture Content: 33.3 %

Sand 1 %, Silt 30 %, Clay 69 %

Initial Dry Density: 1162 kg/m3

Initial Moisture Content: 35.4 %

Initial Volume: 906.0 cm3

Stabilizer Dosage: FUJIBETON %

Volume After Curing: --- cm3

FLYASH 6 %

Final Moisture Content: 42.6 %

CEMENT %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 560 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm3)	WEIGHT AFTER THAWING AND BRUSHING (g)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated during initial curing period

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1320 kg/m³

Sample: Drumheller

Design Optimum Moisture Content: 30.0 %

Sand 1 %, Silt 30 %, Clay 69 %

Initial Dry Density: 1229 kg/m³

Initial Moisture Content: 33.7 %

Initial Volume: 928.6 cm³

Stabilizer Dosage: FUJIBETON %

Volume After Curing: --- cm³

FLYASH 6 %

Final Moisture Content: 61.6 %

CEMENT %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 560 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm³)	WEIGHT AFTER THAWING AND BRUSHING (g)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated during initial curing period

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1305 kg/m3

Sample: Drumheller

Design Optimum Moisture Content: 30.0 %

Sand 1 %, Silt 30 %, Clay 69 %

Initial Dry Density: 1234 kg/m3

Initial Moisture Content: 29.9 %

Initial Volume: 946.9 cm3

Stabilizer Dosage: FUJIBETON %

Volume After Curing: --- cm3

FLYASH 12 %

Final Moisture Content: 39.2 %

CEMENT %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 560 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm3)	WEIGHT AFTER THAWING AND BRUSHING (g)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated during initial curing period

EBA Engineering Consultants Ltd.

eba

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1360 kg/m3

Sample: Drumheller

Design Optimum Moisture Content: 31.0 %

Sand 1 %, Silt 30 %, Clay 69 %

Initial Dry Density: 1259 kg/m3

Initial Moisture Content: 30.3 %

Initial Volume: 922.9 cm3

Stabilizer Dosage: FUJIBETON ______ %

Volume After Curing: --- cm3

FLYASH 12 %

Final Moisture Content: 57.0 %

CEMENT ______ %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 560 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm3)	WEIGHT AFTER THAWING AND BRUSHING (g)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated during initial curing period

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1315 kg/m^3

Sample: Drumheller

Sand 1 %, Silt 30 %, Clay 69 %

Design Optimum Moisture Content: 30.0 %

Initial Dry Density: 1228 kg/m^3

Initial Moisture Content: 30.9 %

Initial Volume: 913.2 cm^3

Stabilizer Dosage: FUJIBETON ____ %

FLYASH 16 %

CEMENT ____ %

Volume After Curing: --- cm^3

Final Moisture Content: 42.6 %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 560 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm^3)	WEIGHT AFTER THAWING AND BRUSHING (g)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated during initial curing period

EBA Engineering Consultants Ltd.

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1350 kg/m^3

Sample: Drumheller

Design Optimum Moisture Content: 26.0 %

Sand 1 %, Silt 30 %, Clay 69 %

Initial Dry Density: 1268 kg/m^3

Initial Moisture Content: 29.5 %

Initial Volume: 934.6 cm^3

Stabilizer Dosage: FUJIBETON %

Volume After Curing: --- cm^3

FLYASH 16 %

Final Moisture Content: 54.5 %

CEMENT %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 560 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm^3)	WEIGHT AFTER THAWING AND BRUSHING (g)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated during initial curing period

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1350 kg/m³

Sample: Drumheller

Sand 1 %, Silt 30 %, Clay 69 %

Design Optimum Moisture Content: 30.0 %

Initial Dry Density: 1318 kg/m³

Initial Moisture Content: 25.5 %

Initial Volume: 932.2 cm³

Stabilizer Dosage: FUJIBETON ____ %

FLYASH 9 %

CEMENT 3 %

Volume After Curing: --- cm³

Final Moisture Content: --- %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 560 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm³)	WEIGHT AFTER THAWING AND BRUSHING (g)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated during initial curing period

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1335 kg/m³

Sample: Drumheller

Design Optimum Moisture Content: 30.0 %

Sand 1 %, Silt 30 %, Clay 69 %

Initial Dry Density: 1307 kg/m³

Initial Moisture Content: 28.1 %

Initial Volume: 939.4 cm³

Stabilizer Dosage: FUJIBETON %

Volume After Curing: --- cm³

FLYASH 9 %

Final Moisture Content: 45.9 %

CEMENT 3 %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 560 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm³)	WEIGHT AFTER THAWING AND BRUSHING (g)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated during initial curing period

APPENDIX F

LABORATORY TEST RESULTS
BASHAW

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1SD83 - 00026

Project No.: 314 - 1264.02

Stabilizer Dosage: FUJIBETON 0 %

Sample: Bashaw

FLYASH 0 %

Sand 91% , Silt 7% , Clay 2%

CEMENT 0 %

TEST DATA:

1) Method of Sample Preparation: ASTM D 558 - 57

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m^3)
1	0.0	1664
2	5.1	1810
3	9.1	1948
4	15.1	1762
5	18.4	1722

Design Field Optimum Moisture Content: 10.0 %

Design Field Maximum Dry Density: 2000 kg/m^3

2) Method of Sample Preparation: ASTM D558 - 57, but using 19 blows to compact each layer instead of 25 blows

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m^3)
1	0.0	1663
2	4.5	1772
3	9.3	1876
4	13.2	1801
5	15.1	1751

Design Field Optimum Moisture Content: 9.5 %

Design Field Maximum Dry Density: 1880 kg/m^3

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

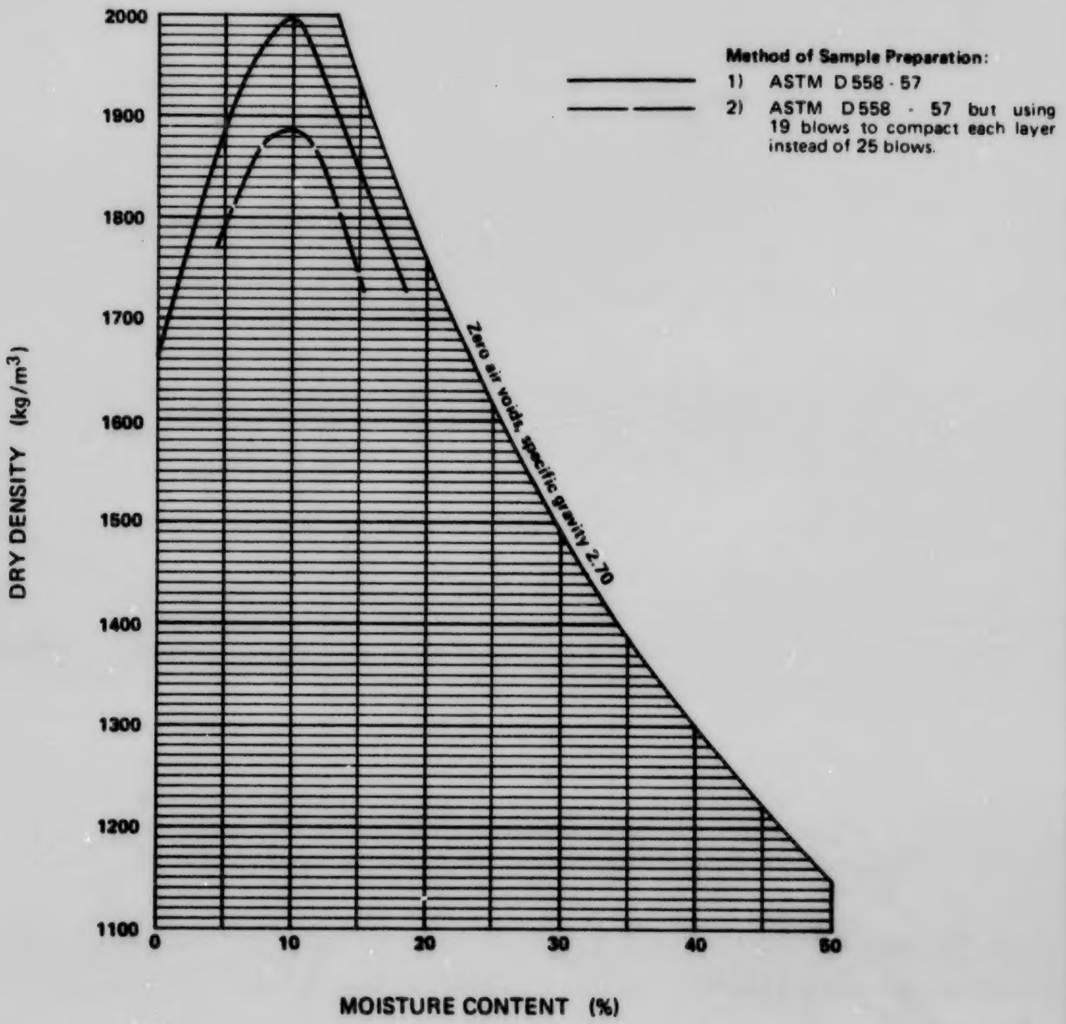
Stabilizer Dosage: FUJIBETON 0 %

Sample: Bashaw

FLYASH 0 %

Sand 91%, Silt 7%, Clay 2%

CEMENT 0 %



SHEET 2 OF 2

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1SD83 - 00026

Project No.: 314 - 1264.02

Stabilizer Dosage: FUJIBETON 0 %

Sample: Bashaw

FLYASH 0 %

Sand 91%, Silt 7%, Clay 2%

CEMENT 0 %

TEST DATA:

1) Method of Sample Preparation: ASTM D 558 - 57

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m3)
1	0.0	1726
2	4.9	1822
3	10.1	2067*
4	15.4	1740
5	20.6	1703

* Note: Density considered unrealistically high for field achievement.

Design Field Optimum Moisture Content: 10.0 %

Design Field Maximum Dry Density: 2000 kg/m3

2) Method of Sample Preparation: ASTM D558 - 57, but using 19 blows to compact each layer instead of 25 blows

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m3)
1	0.4	1653.1
2	4.2	1734.7
3	8.8	1870.9
4	14.6	1757.2
5	19.5	1686.7

Design Field Optimum Moisture Content: 9.5 %

Design Field Maximum Dry Density: 1880 kg/m3

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

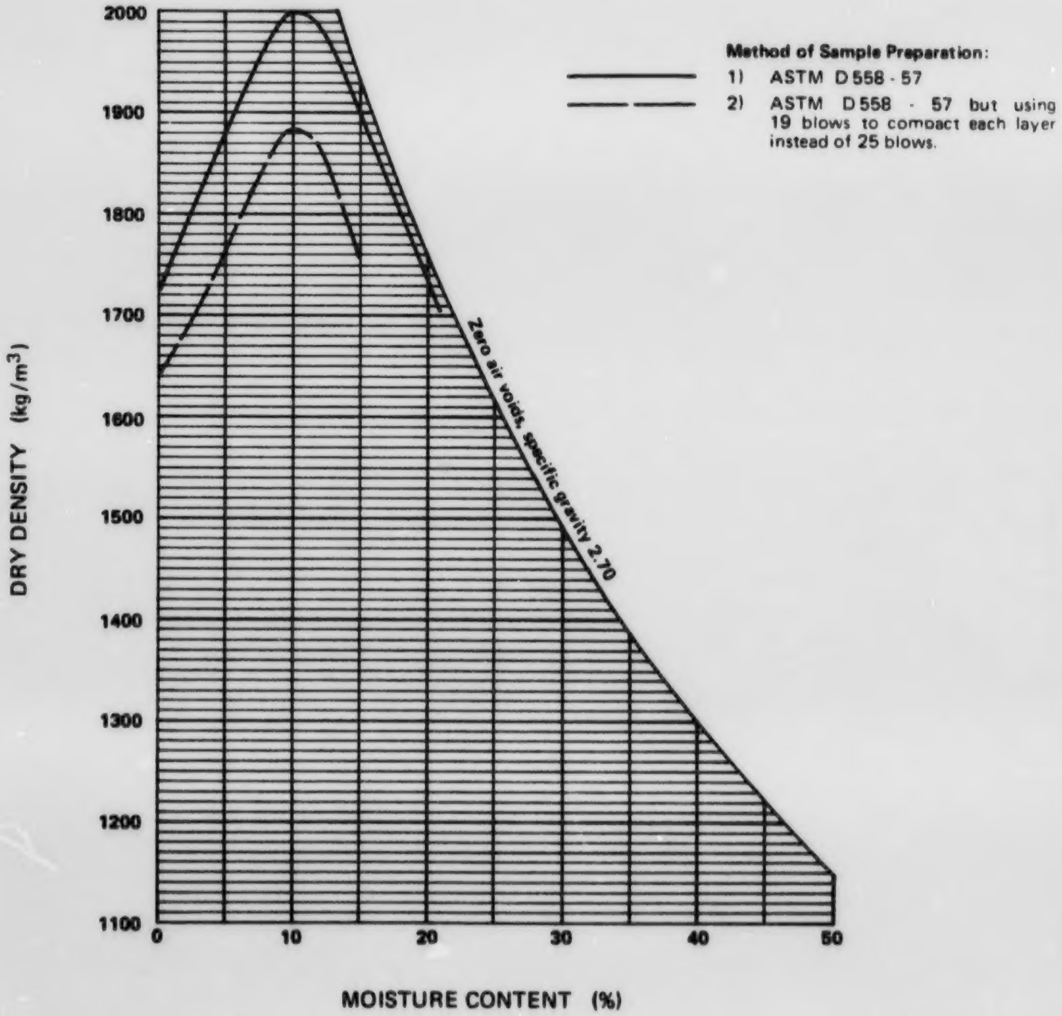
Stabilizer Dosage: FUJIBETON 0 %

Sample: Bashaw

FLYASH 0 %

Sand 91 %, Silt 7 %, Clay 2 %

CEMENT 0 %



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Stabilizer Dosage: None

Sample: Bashaw

Sand 91%, Silt 7%, Clay 2%

Samples compacted using 100% of standard energy

TEST	DRY DENSITY (kg/m^3)	MOISTURE CONTENT (%)	CALIFORNIA BEARING RATIO (%)	
			2.5 mm Penetration	5.0 mm Penetration
1	1726	0.0	12	9.9
2	1822	4.9	32	30
3	2067	10.1	25	28
4	1703	20.6	0.6	0.5
5	1740	15.4	0.7	0.8
6	1664	0.0	12	11
7	1810	5.1	22	24
8	1948	9.1	32	45
9	1762	15.1	1.7	2.3
10	1722	18.4	0.0	0.0

CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02 Stabilizer Dosage: None

Sample: BASHAW

Sand 91% , Silt 7% , Clay 2%

Samples compacted using 75 % of standard energy

TEST	DRY DENSITY (kg/m^3)	MOISTURE CONTENT (%)	CALIFORNIA BEARING RATIO (%)	
			2.5 mm Penetration	5.0 mm Penetration
1	1653	0.4	14	16
2	1735	4.2	20	21
3	1871	8.8	20	26
4	1757	14.6	0.8	0.8
5	1687	19.5	0.0	0.0
6	1663	0.0	18	19
7	1772	4.5	12	18
8	1876	9.3	23	25
9	1801	13.2	0.8	1.1
10	1751	15.1	0.3	0.4

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

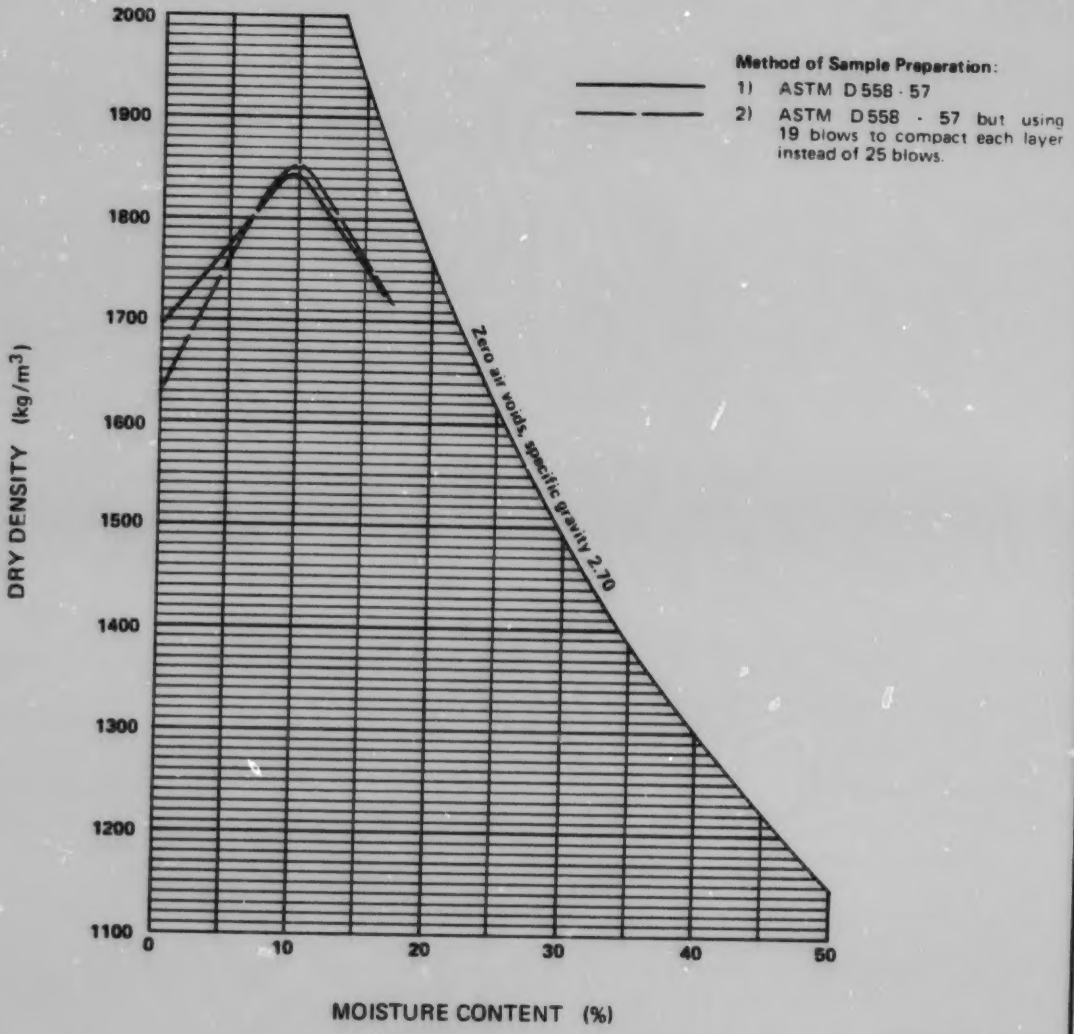
Stabilizer Dosage: FUJIBETON 1 %

Sample: Bashaw

FLYASH %

Sand 91 %, Silt 7 %, Clay 2 %

CEMENT %



DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1SD83 - 00026

Project No.: 314 - 1264.02

Stabilizer Dosage: FUJIBETON 1 %

FLYASH %

CEMENT %

Sample: Bashaw

Sand 91%, Silt 7%, Clay 2%

TEST DATA:

1) Method of Sample Preparation: ASTM D 558 - 57

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m^3)
1	6.3	1795
2	0.0	1696
3	9.6	1846
4	14.2	1775
5	16.7	1728

Design Field Optimum Moisture Content: 9.5 %

Design Field Maximum Dry Density: 1845 kg/m^3

2) Method of Sample Preparation: ASTM D558 - 57, but using 19 blows to compact each layer instead of 25 blows

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m^3)
1	0.0	1630
2	4.9	1756
3	9.4	1851
4	13.9	1775
5	16.2	1718

Design Field Optimum Moisture Content: 9.9 %

Design Field Maximum Dry Density: 1853 kg/m^3

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1SD83 - 00026

Project No.: 314 - 1264.02

Stabilizer Dosage: FUJIBETON 2 %

Sample: Bashaw

FLYASH %

Sand 91%, Silt 7%, Clay 2%

CEMENT %

TEST DATA:

1) Method of Sample Preparation: ASTM D 558 - 57

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	5.1	1791
2	10.5	1873
3	0.0	1697
4	14.3	1804
5	19.1	1702

Design Field Optimum Moisture Content: 10.2 %

Design Field Maximum Dry Density: 1872 kg/m³

2) Method of Sample Preparation: ASTM D558 - 57, but using 19 blows to compact each layer instead of 25 blows

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	4.8	1746
2	11.3	1824
3	13.8	1788
4	20.2	1653
5		

Design Field Optimum Moisture Content: 9.5 %

Design Field Maximum Dry Density: 1855 kg/m³

SHEET 1 OF 2

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

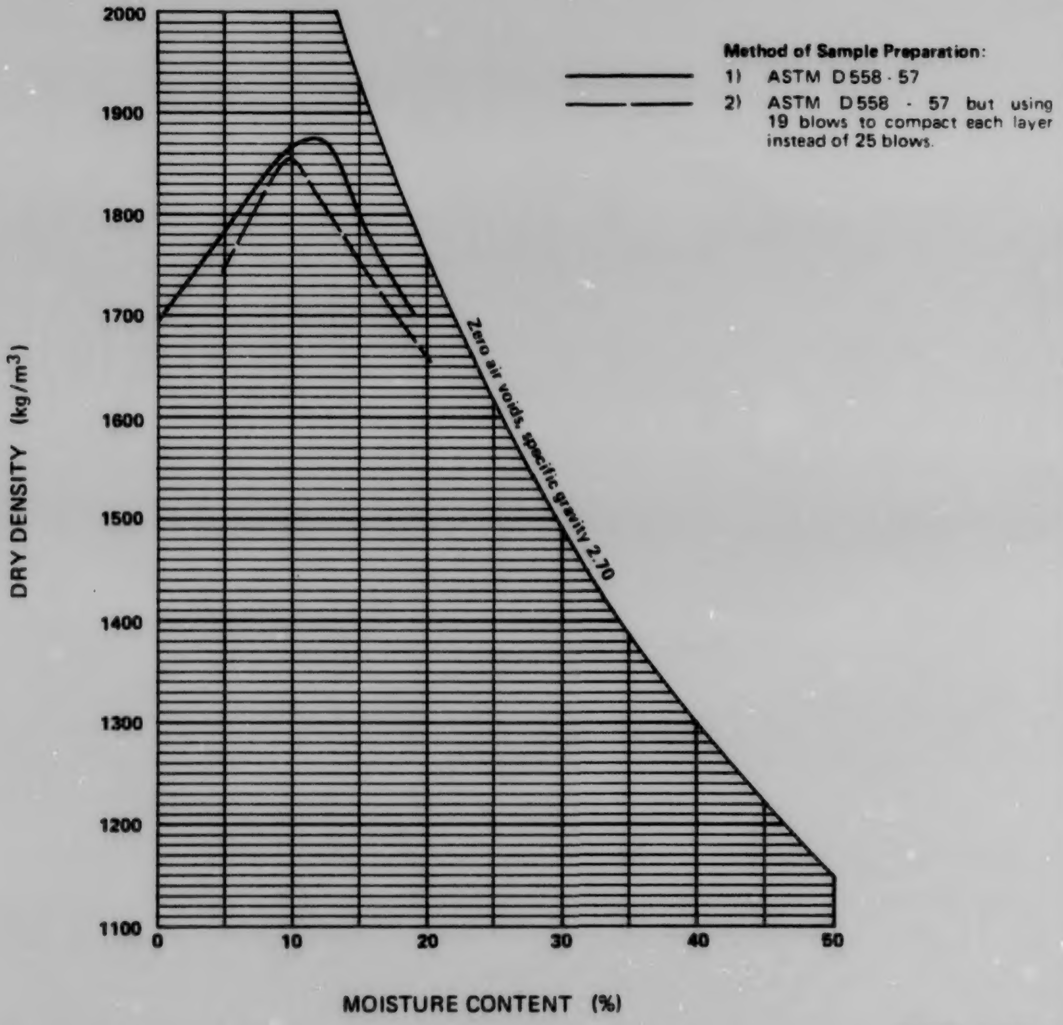
Stabilizer Dosage: FUJIBETON 2 %

Sample: Bashaw

FLYASH %

Sand 91 %, Silt 7 %, Clay 2 %

CEMENT %



SHEET 2 OF 2

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1SD83 - 00026

Project No.: 314 - 1264.02

Stabilizer Dosage: FUJIBETON 4 %

Sample: Bashaw

FLYASH %

Sand 91%, Silt 7%, Clay 2%

CEMENT %

TEST DATA:

1) Method of Sample Preparation: ASTM D 558 - 57

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	0.0	1717
2	4.8	1813
3	9.3	1922
4	14.3	1793
5	17.9	1688

Design Field Optimum Moisture Content: 8.6 %

Design Field Maximum Dry Density: 1920 kg/m³

2) Method of Sample Preparation: ASTM D558 - 57, but using 19 blows to compact each layer instead of 25 blows

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	0.0	1675
2	4.2	1762
3	9.1	1855
4	12.0	1798
5	15.4	1731

Design Field Optimum Moisture Content: 9.0 %

Design Field Maximum Dry Density: 1855 kg/m³

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

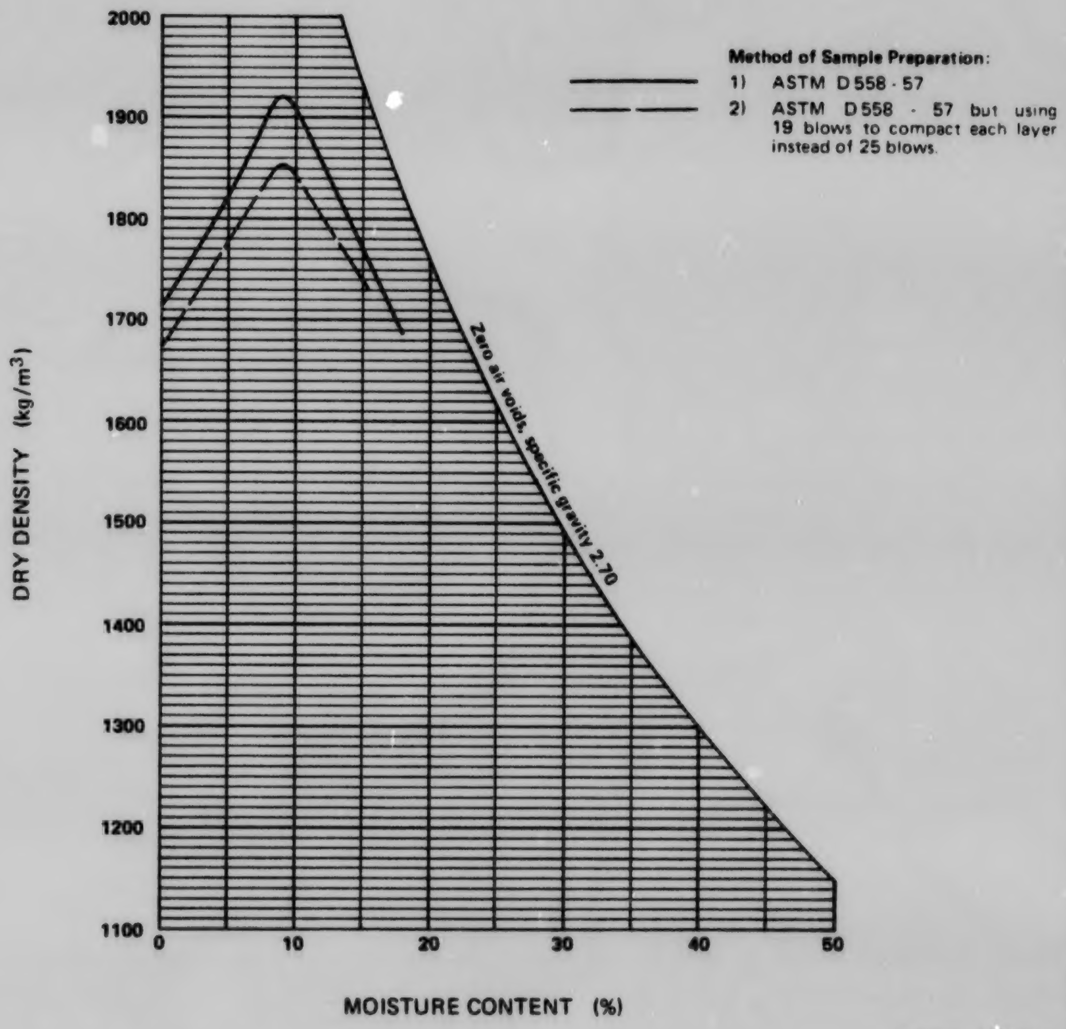
Stabilizer Dosage: FUJIBETON 4 %

FLYASH %

CEMENT %

Sample: Bashaw

Sand 91 %, Silt 7 %, Clay 2 %



SHEET 2 OF 2

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1SD83 - 00026

Project No.: 314 - 1264.02

Stabilizer Dosage: FUJIBETON 6 %

FLYASH %

CEMENT %

Sample: Bashaw

Sand 91%, Silt 7%, Clay 2%

TEST DATA:

1) Method of Sample Preparation: ASTM D 558 - 57

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m3)
1	0.0	1725
2	5.3	1798
3	10.1	1920
4	14.2	1788
5	16.6	1738

Design Field Optimum Moisture Content: 9.6 %

Design Field Maximum Dry Density: 1920 kg/m3

2) Method of Sample Preparation: ASTM D558 - 57, but using 19 blows to compact each layer instead of 25 blows

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m3)
1	1.0	1691
2	4.7	1766
3	10.0	1864
4	14.6	1789
5	16.7	1720

Design Field Optimum Moisture Content: 11.0 %

Design Field Maximum Dry Density: 1870 kg/m3

SHEET 1 OF 2

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

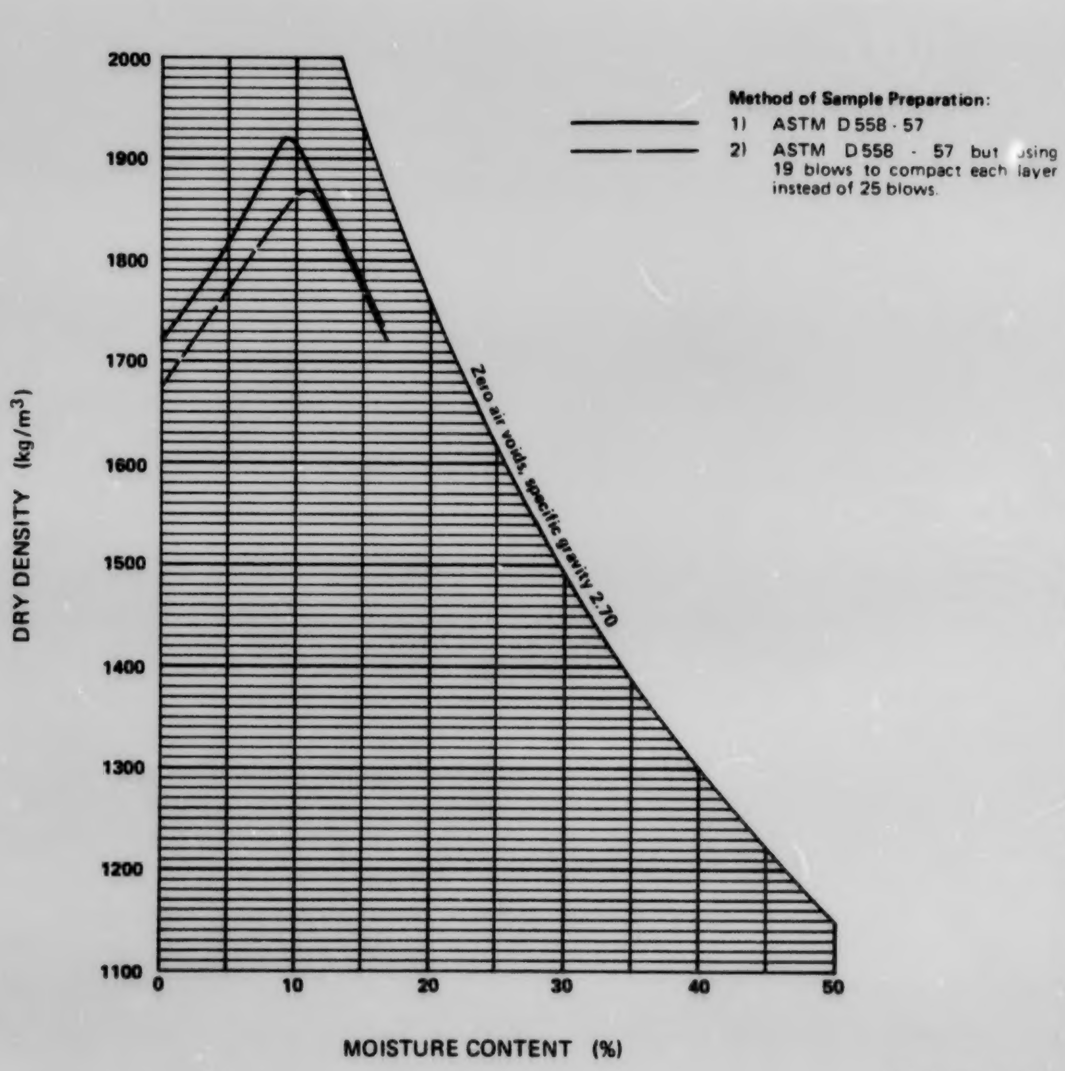
Stabilizer Dosage: FUJIBETON 6 %

Sample: Bashaw

FLYASH %

Sand 91 %, Silt 7 %, Clay 2 %

CEMENT %



EBA Engineering Consultants Ltd.

eba

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1SD83 - 00026

Project No.: 314 - 1264.02

Stabilizer Dosage: FUJIBETON 10 %

FLYASH %

CEMENT %

Sample: Bashaw

Sand 91%, Silt 7%, Clay 2%

TEST DATA:

1) Method of Sample Preparation: ASTM D 558 - 57

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	0.0	1740
2	4.8	1845
3	9.1	1951
4	13.8	1828
5	16.5	1748

Design Field Optimum Moisture Content: 8.7 %

Design Field Maximum Dry Density: 1950 kg/m³

2) Method of Sample Preparation: ASTM D558 - 57, but using 19 blows to compact each layer instead of 25 blows

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	0.0	1731
2	4.6	1766
3	10.0	1886
4	14.7	1777
5	17.1	1701

Design Field Optimum Moisture Content: 9.7 %

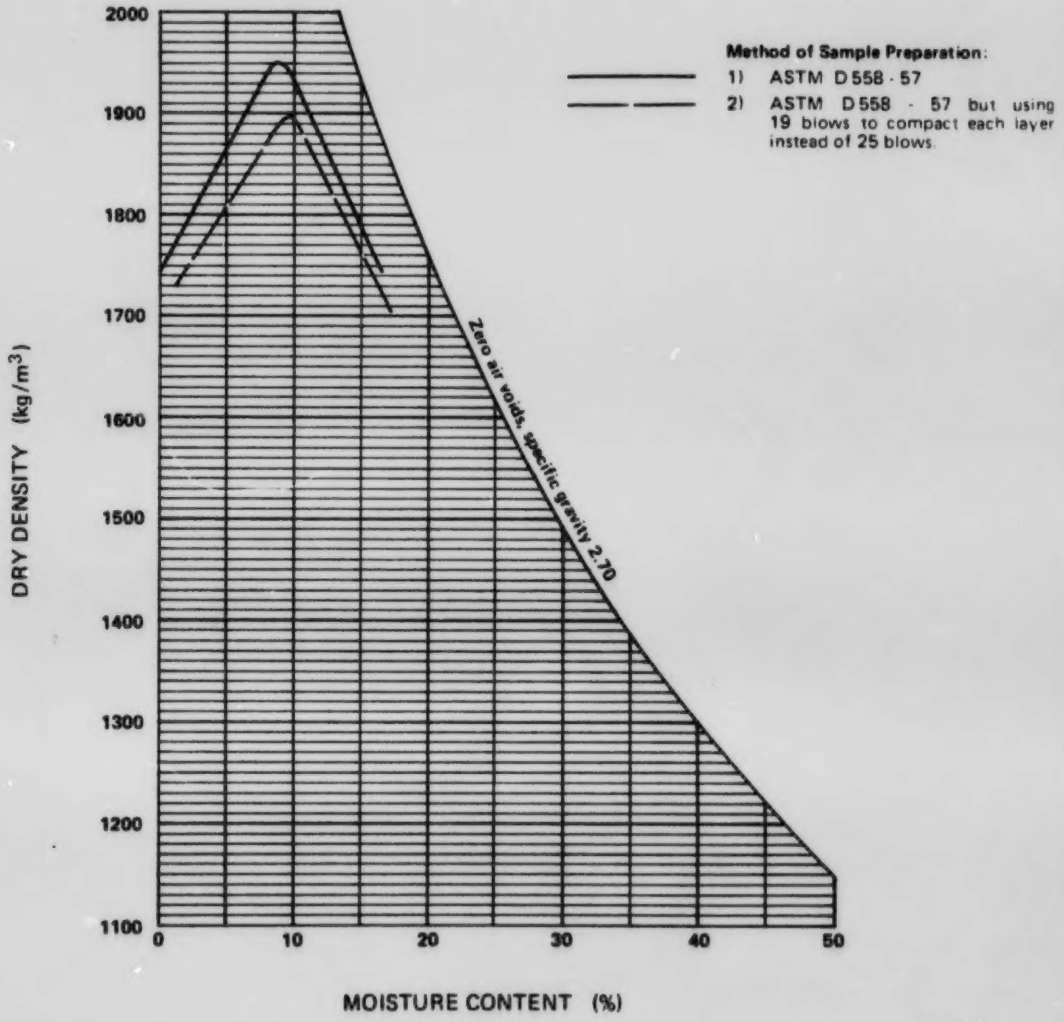
Design Field Maximum Dry Density: 1895 kg/m³

SHEET 1 OF 2

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client:	TRANSPORT CANADA	Contract No.:	1 SD 83 - 00026	
Project No.:	314 - 1264.02	Stabilizer Dosage:	FUJIBETON	10 %
Sample:	Bashaw		FLYASH	%
	Sand 91 %, Silt 7 %, Clay 2 %		CEMENT	%



SHEET 2 OF 2

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA
Contract No.: 1SD83 - 00026

Project No.: 314 - 1264.02
Stabilizer Dosage: FUJIBETON ______ %

Sample: Bashaw
FLYASH 2 %

Sand 91%, Silt 7%, Clay 2%
CEMENT ______ %

TEST DATA:

1) Method of Sample Preparation: ASTM D 558 - 57

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	4.8	1788
2	9.4	1890
3	14.6	1761
4	19.4	1662
5	0.0	1702

Design Field Optimum Moisture Content: 9.0 %

Design Field Maximum Dry Density: 1890 kg/m³

2) Method of Sample Preparation: ASTM D558 - 57, but using 19 blows to compact each layer instead of 25 blows

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	6.0	1666
2	4.8	1752
3	10.3	1846
4	14.5	1782
5	19.2	1685

Design Field Optimum Moisture Content: 10.5 %

Design Field Maximum Dry Density: 1845 kg/m³

EBA Engineering Consultants Ltd.

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

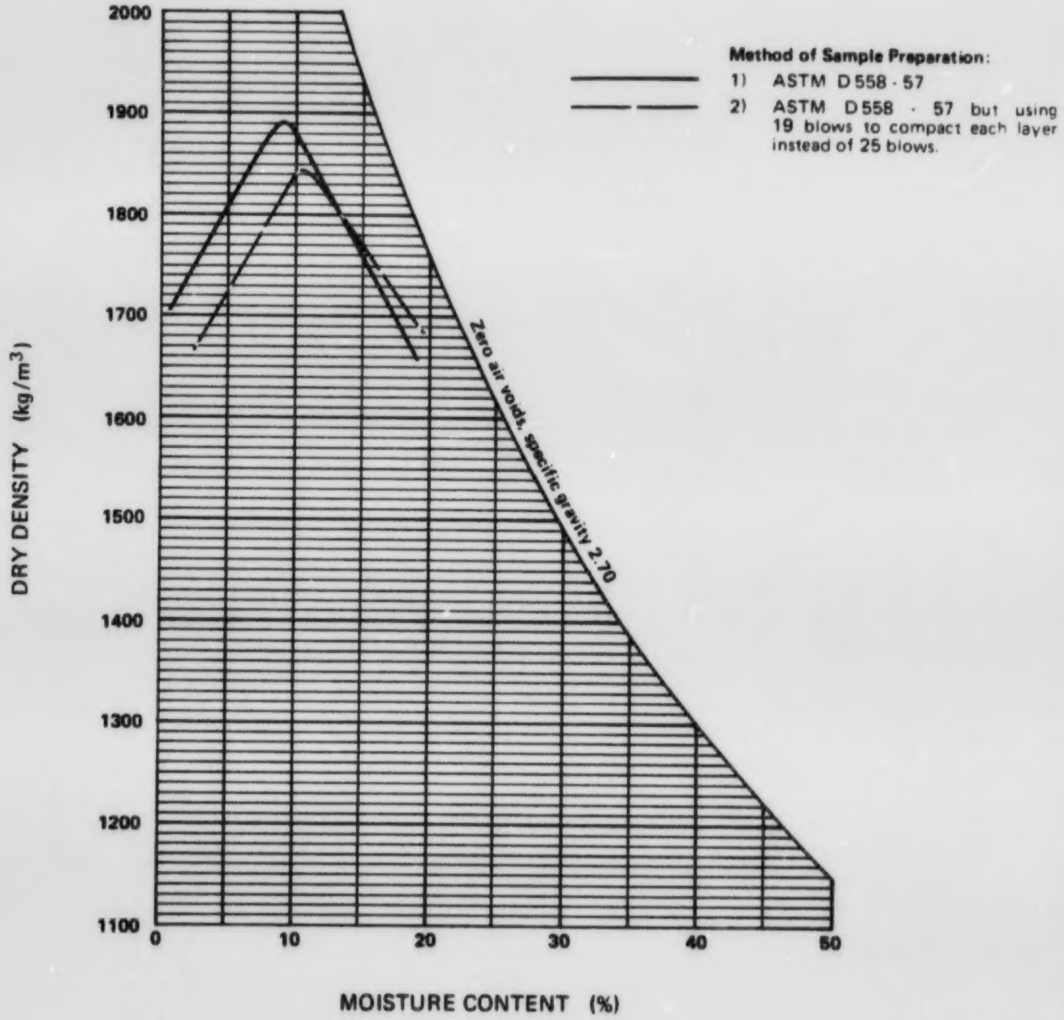
Stabilizer Dosage: FUJIBETON ____ %

Sample: Bashaw

FLYASH 2 %

Sand 91 %, Silt 7 %, Clay 2 %

CEMENT ____ %



SHEET 2 OF 2

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA Contract No.: 1SD83 · 00026

Project No.: 214 · 1264.02 Stabilizer Dosage: FUJIBETON ______ %

Sample: Bashaw FLYASH 4 %

Sand 91%, Silt 7%, Clay 2% CEMENT ______ %

TEST DATA:

1) Method of Sample Preparation: ASTM D 558 · 57

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	4.9	1801
2	9.6	1902
3	14.7	1756
4	18.0	1691
5	0.0	1740

Design Field Optimum Moisture Content: 9.4 %

Design Field Maximum Dry Density: 1890 kg/m³

2) Method of Sample Preparation: ASTM D558 · 57, but using 19 blows to compact each layer instead of 25 blows

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	0.0	1603
2	5.0	1774
3	9.3	1886
4	15.0	1758
5	19.1	1685

Design Field Optimum Moisture Content: 10.1 %

Design Field Maximum Dry Density: 1890 kg/m³

EBA Engineering Consultants Ltd.

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

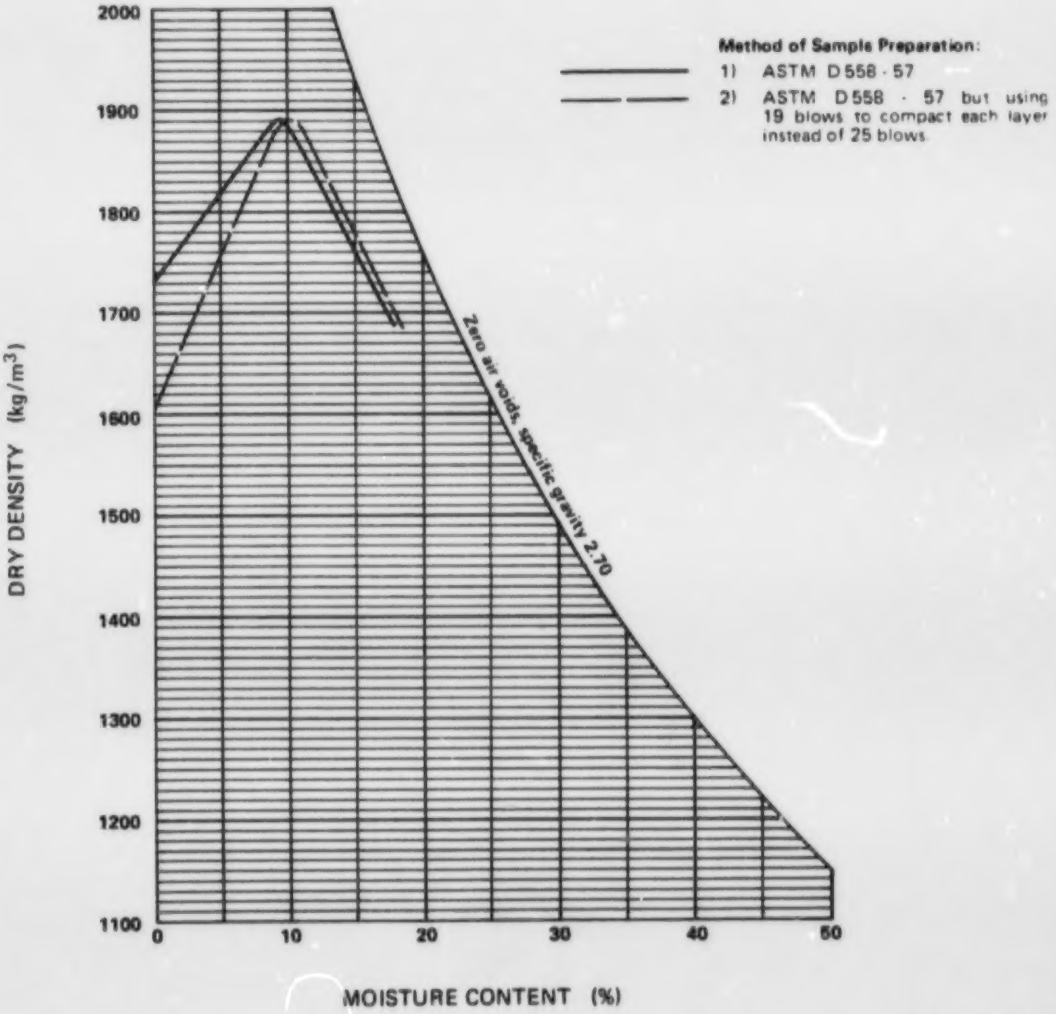
Stabilizer Dosage: FUJIBETON ____ %

Sample: Bashaw

FLYASH 4 %

Sand 91 %, Silt 7 %, Clay 2 %

CEMENT ____ %



SHEET 2 OF 2

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1SD83 - 00026

Project No.: 314 - 1264.02

Stabilizer Dosage: FUJIBETON ____ %

FLYASH 6 %

CEMENT ____ %

Sample: Bashaw

Sand 91%, Silt 7%, Clay 2%

TEST DATA:

1) Method of Sample Preparation: ASTM D 558 - 57

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	4.7	1853
2	9.4	1923
3	14.3	1780
4	19.1	1712
5	0.0	1779

Design Field Optimum Moisture Content: 8.5 %

Design Field Maximum Dry Density: 1927 kg/m³

2) Method of Sample Preparation: ASTM D558 - 57, but using 19 blows to compact each layer instead of 25 blows

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	0.0	1734
2	5.2	1800
3	9.2	1906
4	14.3	1751
5	16.0	1728

Design Field Optimum Moisture Content: 8.7 %

Design Field Maximum Dry Density: 1900 kg/m³

EBA Engineering Consultants Ltd.

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

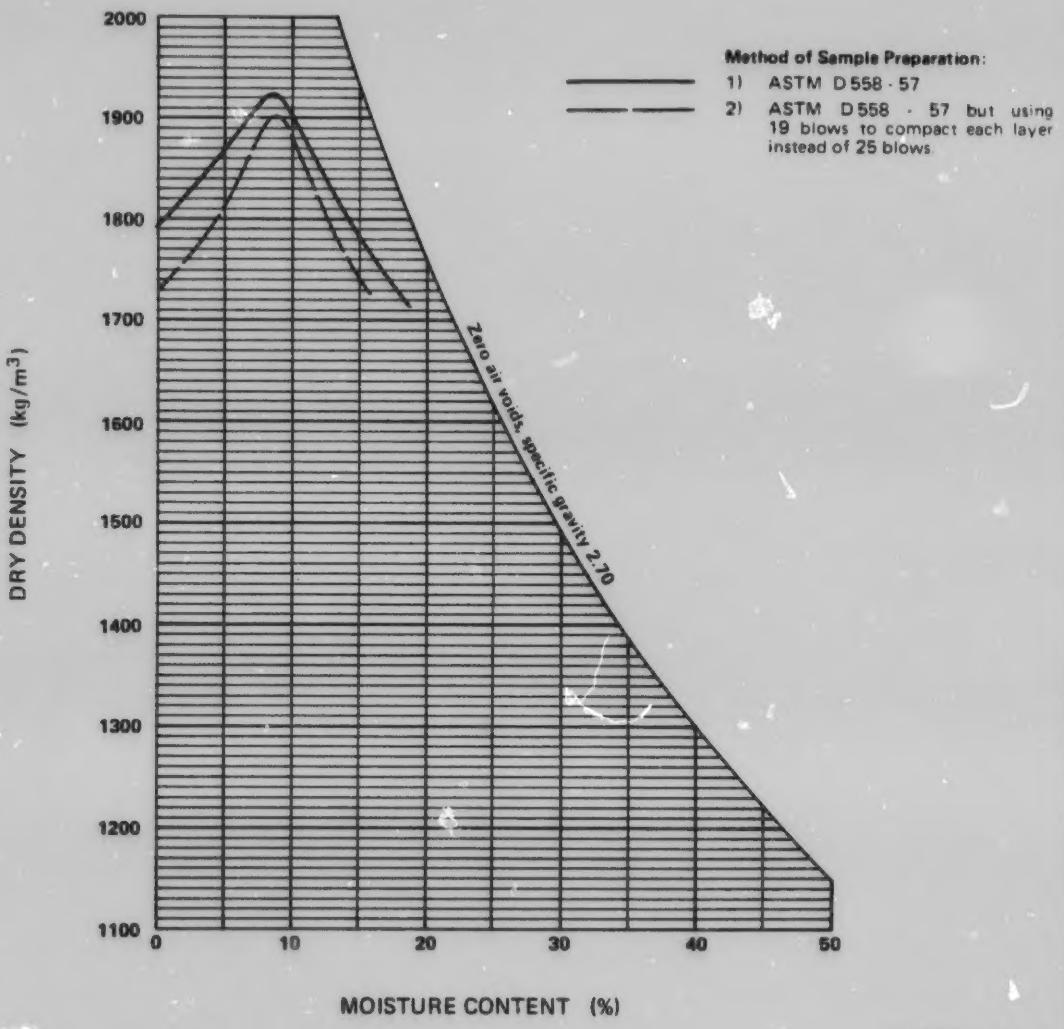
Stabilizer Dosage: FUJIBETON ____ %

FLYASH 6 %

CEMENT ____ %

Sample: Bashaw

Sand 91 %, Silt 7 %, Clay 2 %



SHEET 2 OF 2

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1SD83 - 00026

Project No.: 314 - 1264.02

Stabilizer Dosage: FUJIBETON ______ %

Sample: Bashaw

FLYASH 10 %

Sand 91%, Silt 7%, Clay 2%

CEMENT ______ %

TEST DATA:

1) Method of Sample Preparation: ASTM D 558 - 57

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	0.0	1787
2	4.7	1882
3	9.4	1946
4	14.2	1763
5	16.5	1727

Design Field Optimum Moisture Content: 8.4 %

Design Field Maximum Dry Density: 1945 kg/m³

2) Method of Sample Preparation: ASTM D558 - 57, but using 19 blows to compact each layer instead of 25 blows

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	0.0	1775
2	4.7	1796
3	10.1	1913
4	14.0	1765
5	16.7	1657

Design Field Optimum Moisture Content: 9.1 %

Design Field Maximum Dry Density: 1909 kg/m³

DRY DENSITY / MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

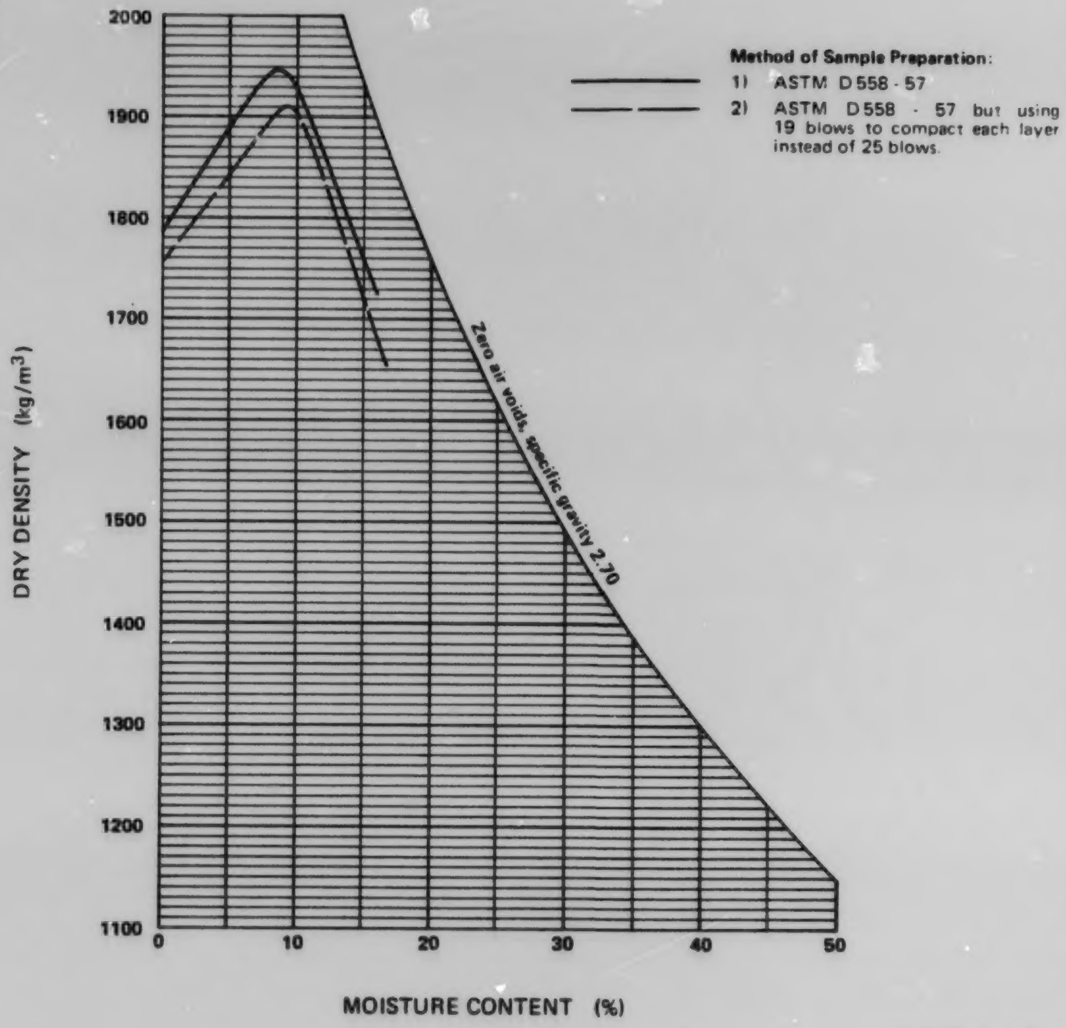
Stabilizer Dosage: FUJIBETON ____ %

Sample: Bashaw

FLYASH 10 %

Sand 91 %, Silt 7 %, Clay 2 %

CEMENT ____ %



SHEET 2 OF 2

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA Contract No.: 1SD83 - 00026

Project No.: 314 - 1264.02 Stabilizer Dosage: FUJIBETON ____ %

Sample: Bashaw FLYASH 2 %

Sand 91%, Silt 7%, Clay 2% CEMENT 3 %

TEST DATA:

1) Method of Sample Preparation: ASTM D 558 - 57

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	0	1678
2	4.7	1790
3	9.1	1916
4	14.3	1781
5	16.9	1718

Design Field Optimum Moisture Content: 9 %

Design Field Maximum Dry Density: 1910 kg/m³

2) Method of Sample Preparation: ASTM D558 - 57, but using 19 blows to compact each layer instead of 25 blows

SPECIMEN	MOISTURE CONTENT (%)	DRY DENSITY (kg/m³)
1	1.0	1705
2	4.7	1775
3	9.4	1883
4	14.1	1785
5	17.5	1702

Design Field Optimum Moisture Content: 9.5 %

Design Field Maximum Dry Density: 1888 kg/m³

SHEET 1 OF 2

DRY DENSITY/MOISTURE CONTENT RELATIONSHIP TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

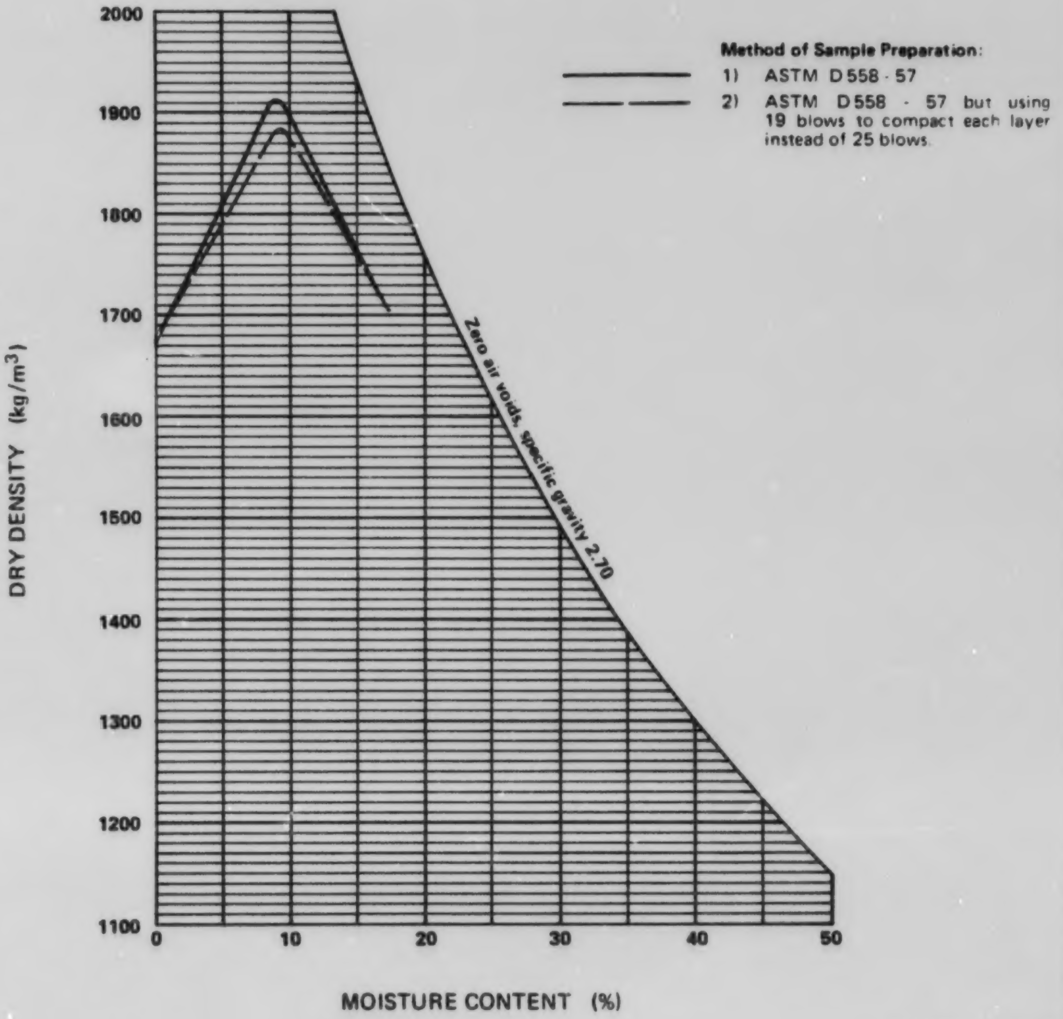
Stabilizer Dosage: FUJIBETON ____ %

Sample: Bashaw

FLYASH 2 %

Sand 91 %, Silt 7 %, Clay 2 %

CEMENT 3 %



SHEET 2 OF 2

CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Bashaw

Sand 91% , Silt 7% , Clay 2%

Initial Dry Density: 1925.4 kg/m^3

Initial Moisture Content: 8.3 %

Stabilizer Dosage: FUJIBETON 1 %

FLYASH %

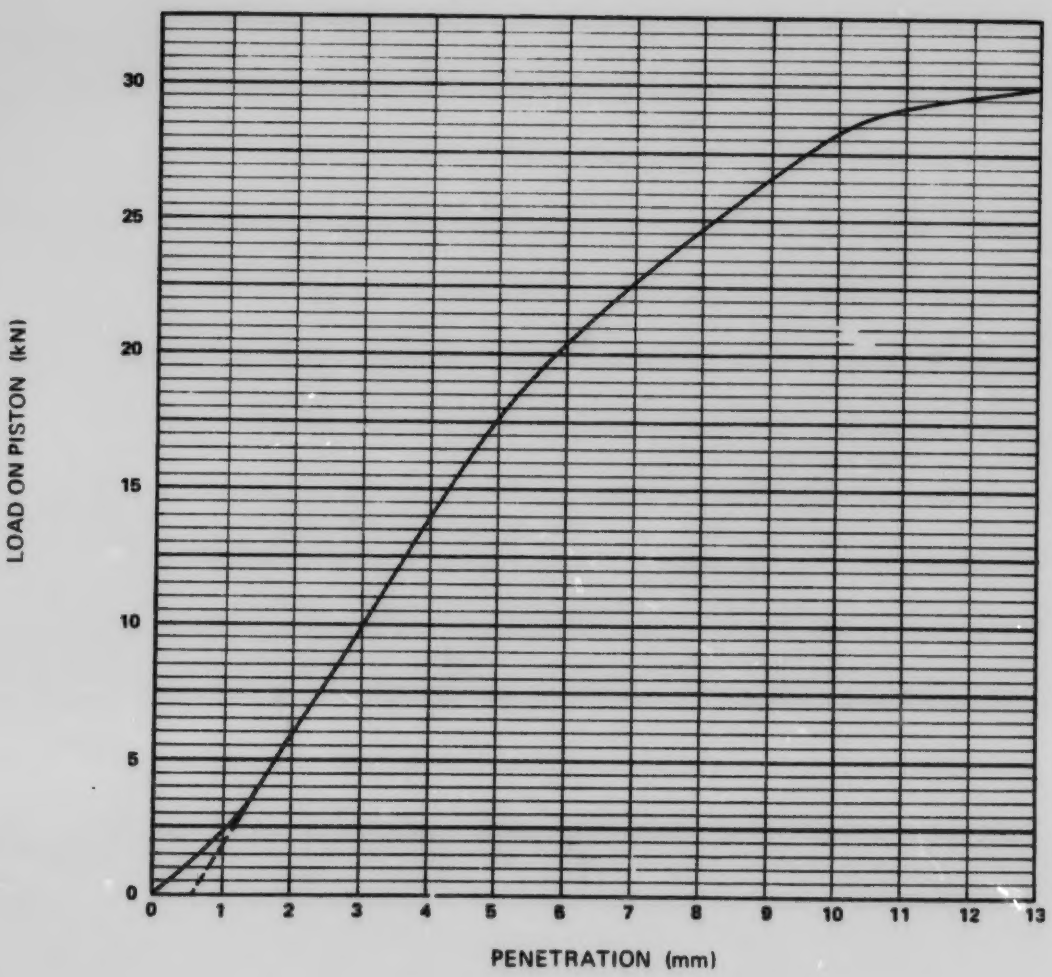
CEMENT %

Final Moisture Content: 10.9 %

California Bearing Ratio: 2.5 mm 79 %

5.0 mm 97 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 100% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Bashaw

Sand 91%, Silt 7%, Clay 2%

Initial Dry Density: 1857 kg/m^3

Initial Moisture Content: 8.9%

Stabilizer Dosage: FUJIBETON 1 %

Final Moisture Content: 11.7 %

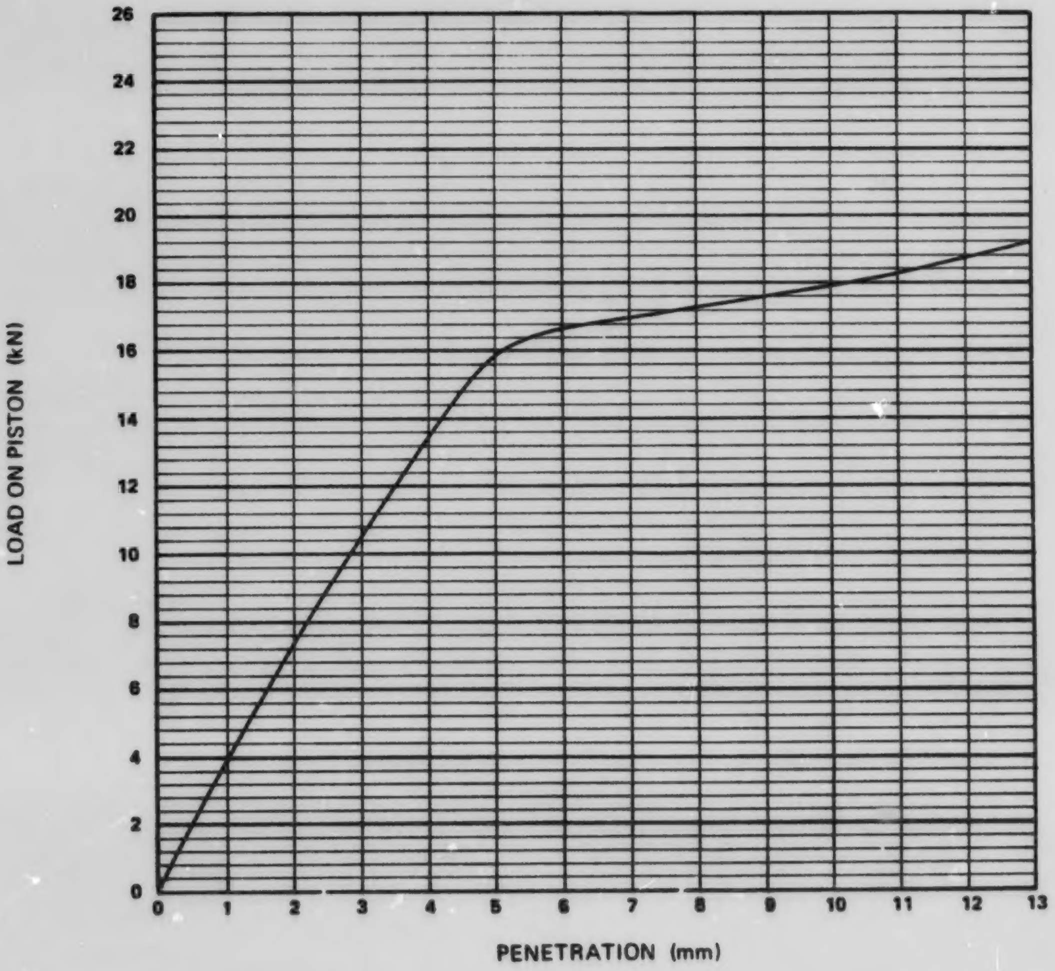
FLYASH %

California Bearing Ratio: 2.5 mm 68 %

CEMENT %

5.0 mm 80 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 75% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Bashaw

Sand 91% , Silt 7% , Clay 2%

Initial Dry Density: 1877.3 kg/m^3

Initial Moisture Content: 9.1 %

Stabilizer Dosage: FUJIBETON 2 %

Final Moisture Content: 9.4 %

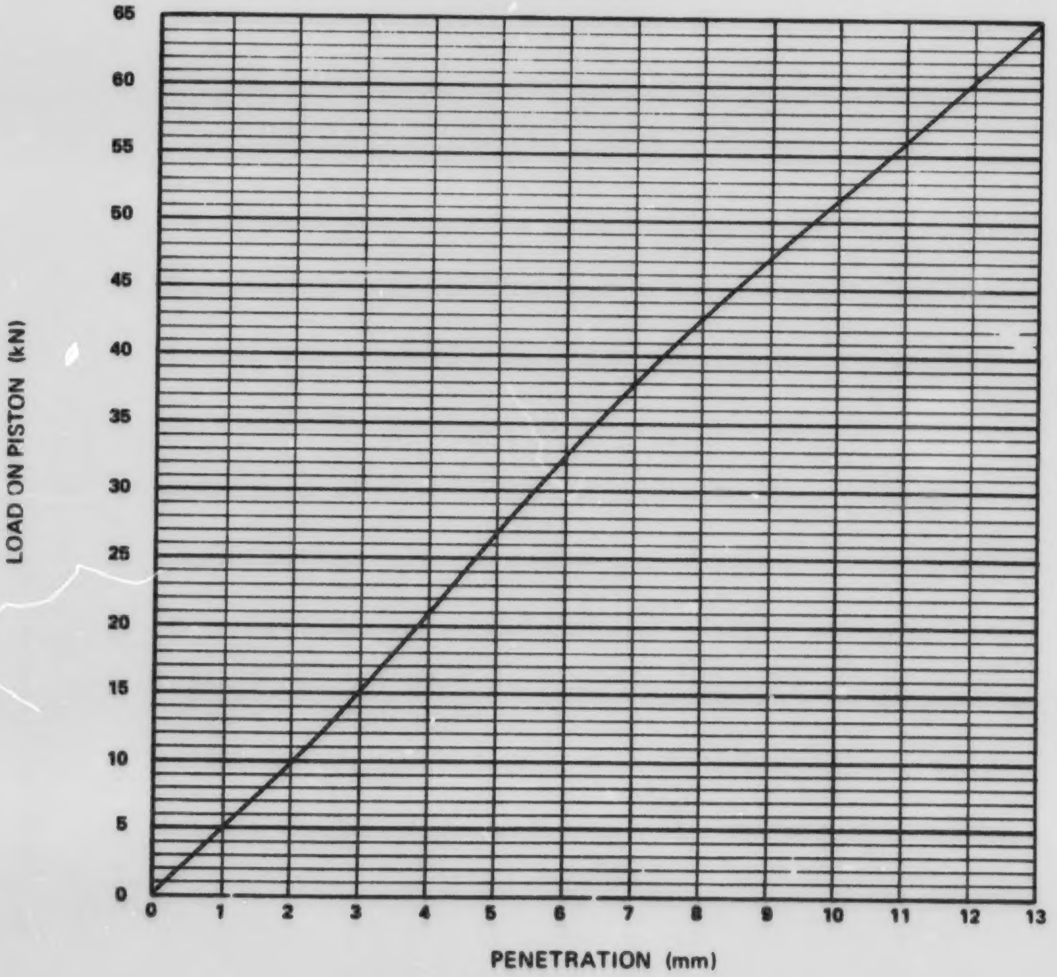
FLYASH %

California Bearing Ratio: 2.5 mm 90 %

CEMENT %

5.0 mm 135 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 100% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Bashaw

Sand 91% , Silt 7% , Clay 2%

Initial Dry Density: 1870 kg/m^3

Initial Moisture Content: 12.0%

Stabilizer Dosage: FUJIBETON 2 %

Final Moisture Content: 10.9%

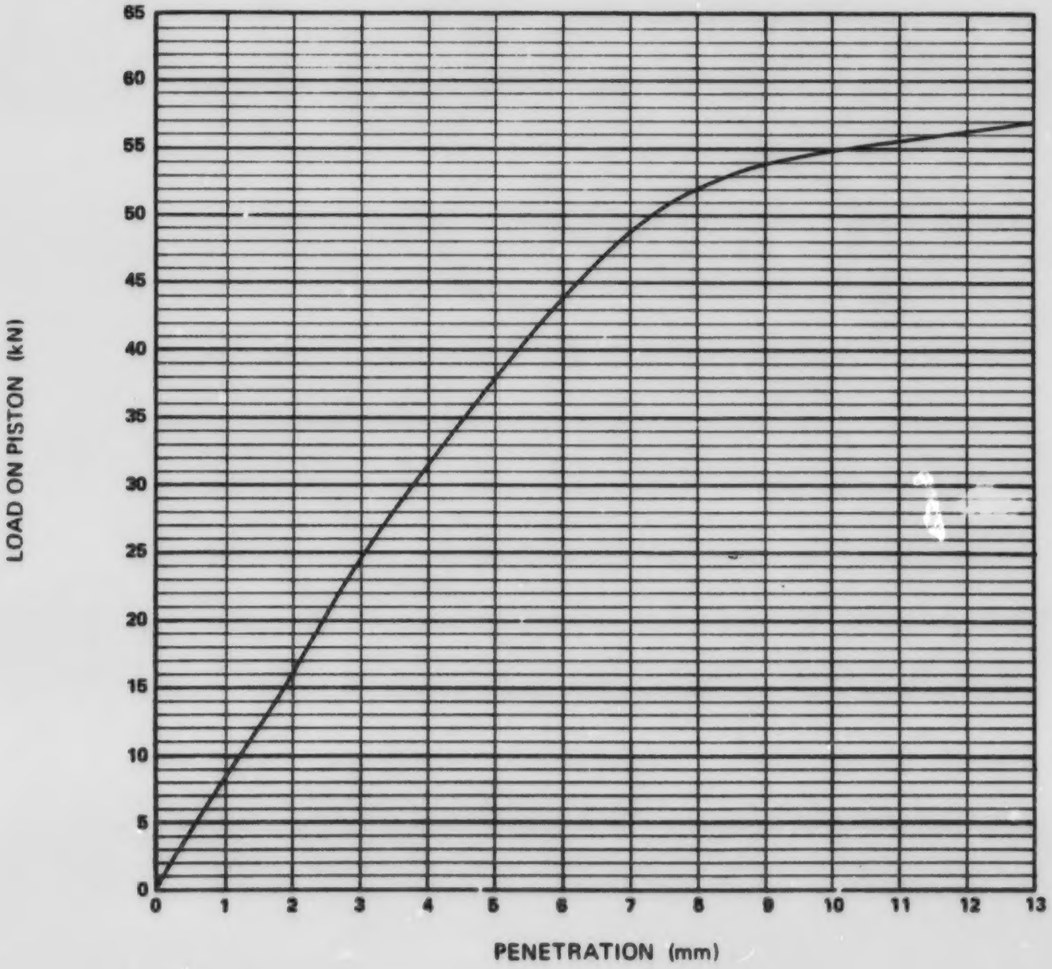
FLYASH %

California Bearing Ratio: 2.5 mm 158%

CEMENT %

5.0 mm 190%

Sample statically compacted to maximum dry density obtained during compaction test performed using 75% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Bashaw

Sand 91% , Silt 7% , Clay 2%

Initial Dry Density: 1877.3 kg/m^3

Initial Moisture Content: 7.4 %

Stabilizer Dosage: FUJIBETON 4 %

Final Moisture Content: 7.8 %

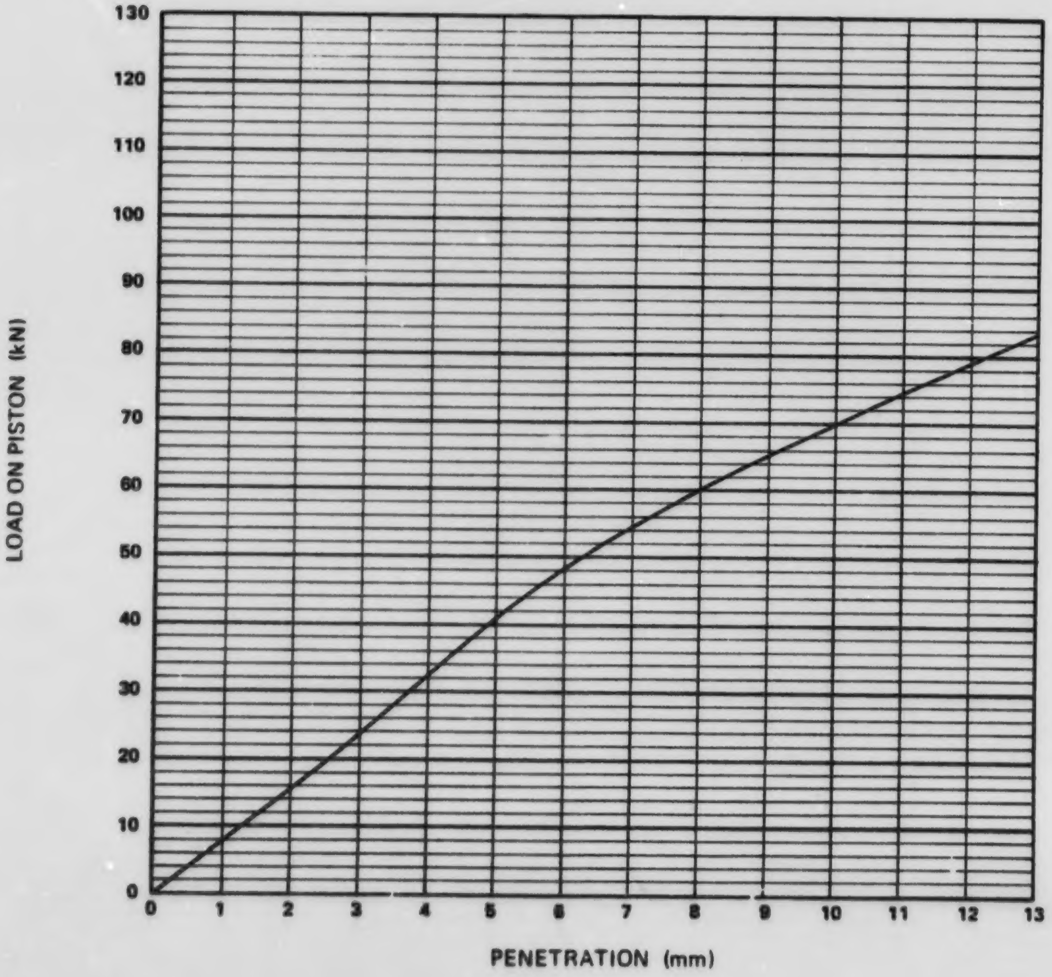
FLYASH ____ %

California Bearing Ratio: 2.5 mm 142 %

CEMENT ____ %

5.0 mm 205 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 100% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Bashaw

Sand 91%, Silt 7%, Clay 2%

Initial Dry Density: 2067.9 kg/m^3

Initial Moisture Content: 8.5%

Stabilizer Dosage: FUJIBETON 4 %

FLYASH %

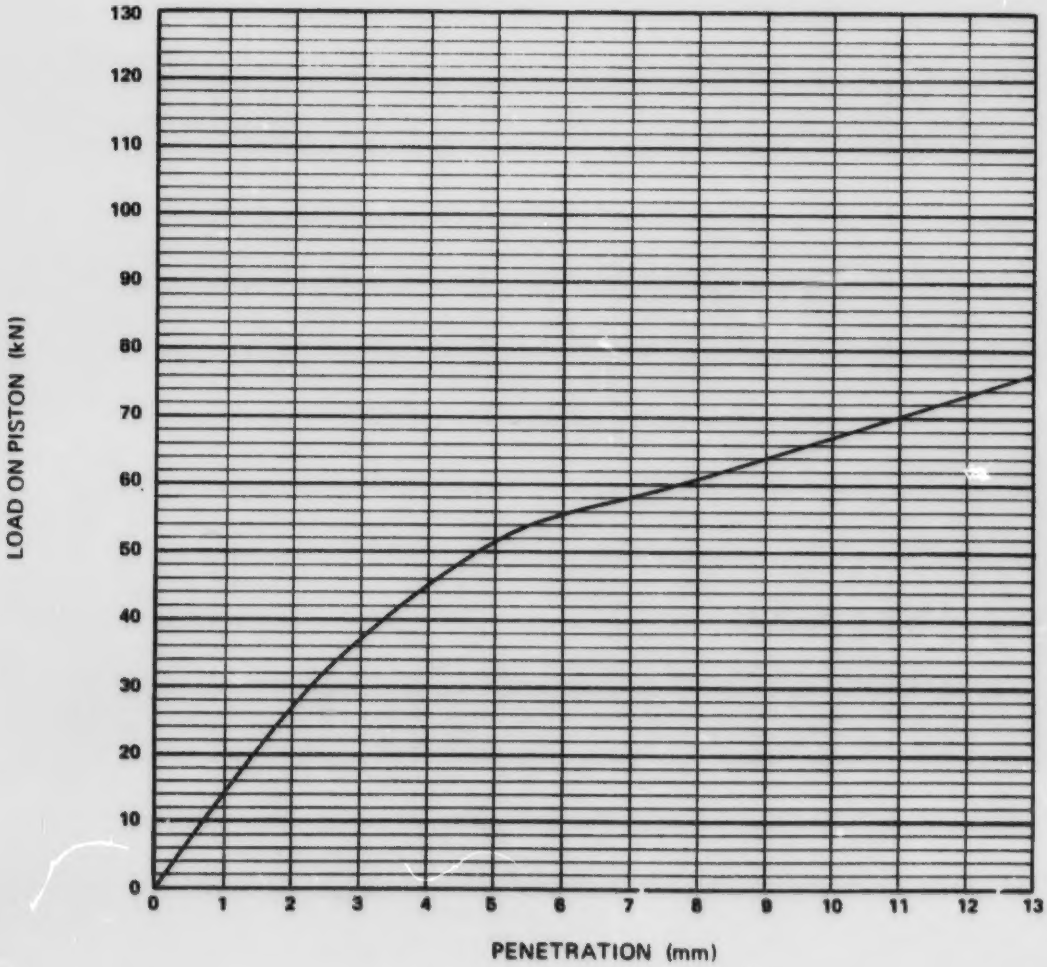
CEMENT %

Final Moisture Content: 10.3%

California Bearing Ratio: 2.5 mm 248%

5.0 mm 260%

Sample statically compacted to maximum dry density obtained during compaction test performed using 75% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Bashaw

Sand 91%, Silt 7%, Clay 2%

Initial Dry Density: 1920.6 kg/m^3

Initial Moisture Content: 9.5 %

Stabilizer Dosage: FUJIBETON 6 %

Final Moisture Content: 9.1 %

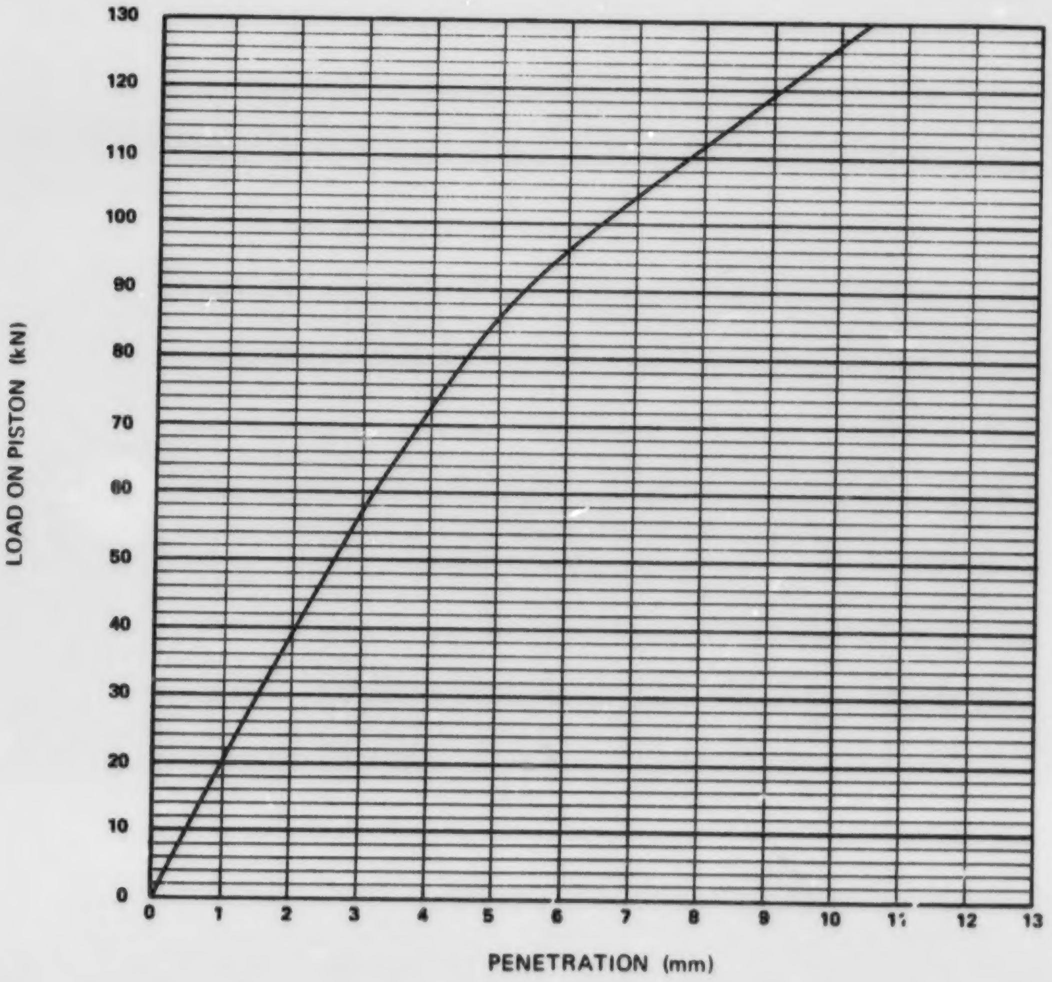
FLYASH %

California Bearing Ratio: 2.5 mm 370 %

CEMENT %

5.0 mm 435 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 100% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 · 00026

Project No.: 314 · 1264.02

Sample: Bashaw

Sand 91%, Silt 7%, Clay 2%

Initial Dry Density: 2071.1 kg/m^3

Initial Moisture Content: 10.7 %

Stabilizer Dosage: FUJIBETON 6 %

Final Moisture Content: 11.2 %

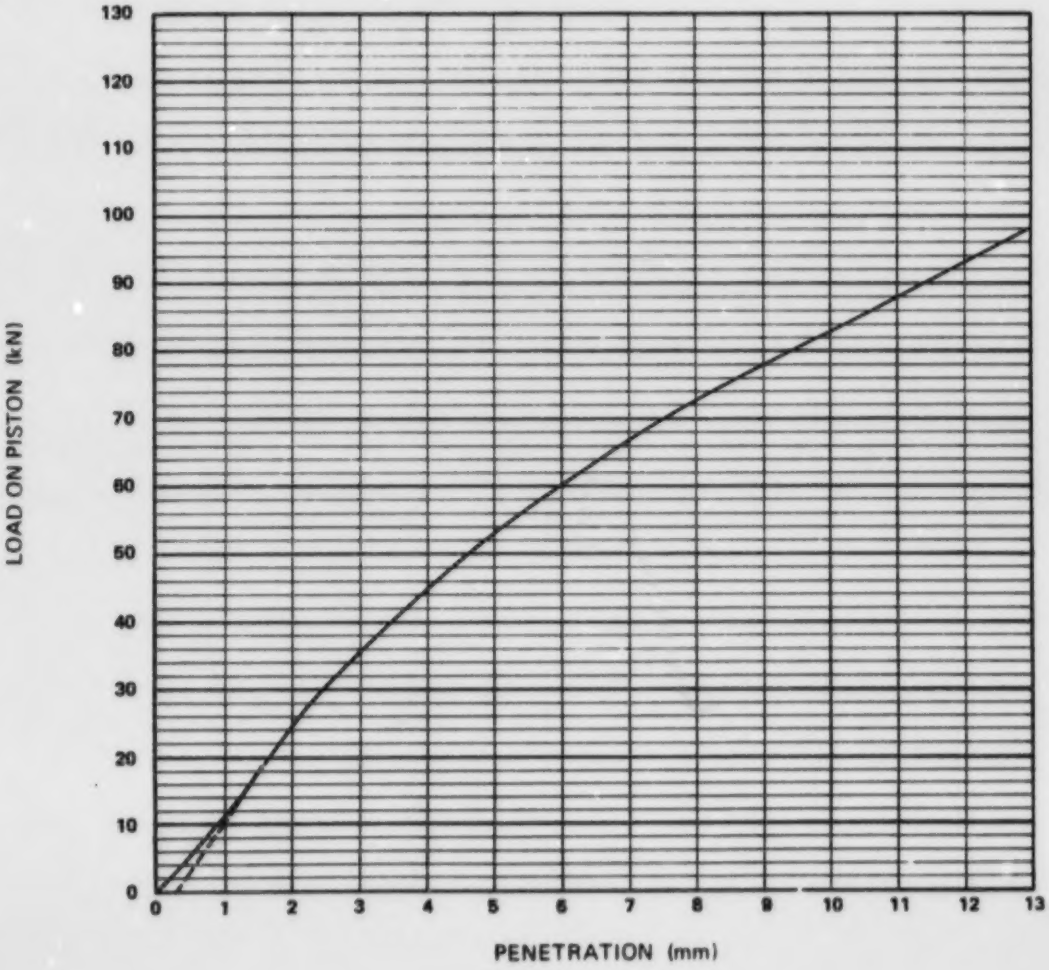
FLYASH %

California Bearing Ratio: 2.5 mm 255 %

CEMENT %

5.0 mm 280 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 75% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Bashaw

Sand 91%, Silt 7%, Clay 2%

Initial Dry Density: 1941.4 kg/m^3

Initial Moisture Content: 8.7 %

Stabilizer Dosage: FUJIBETON 10 %

Final Moisture Content: 8.2 %

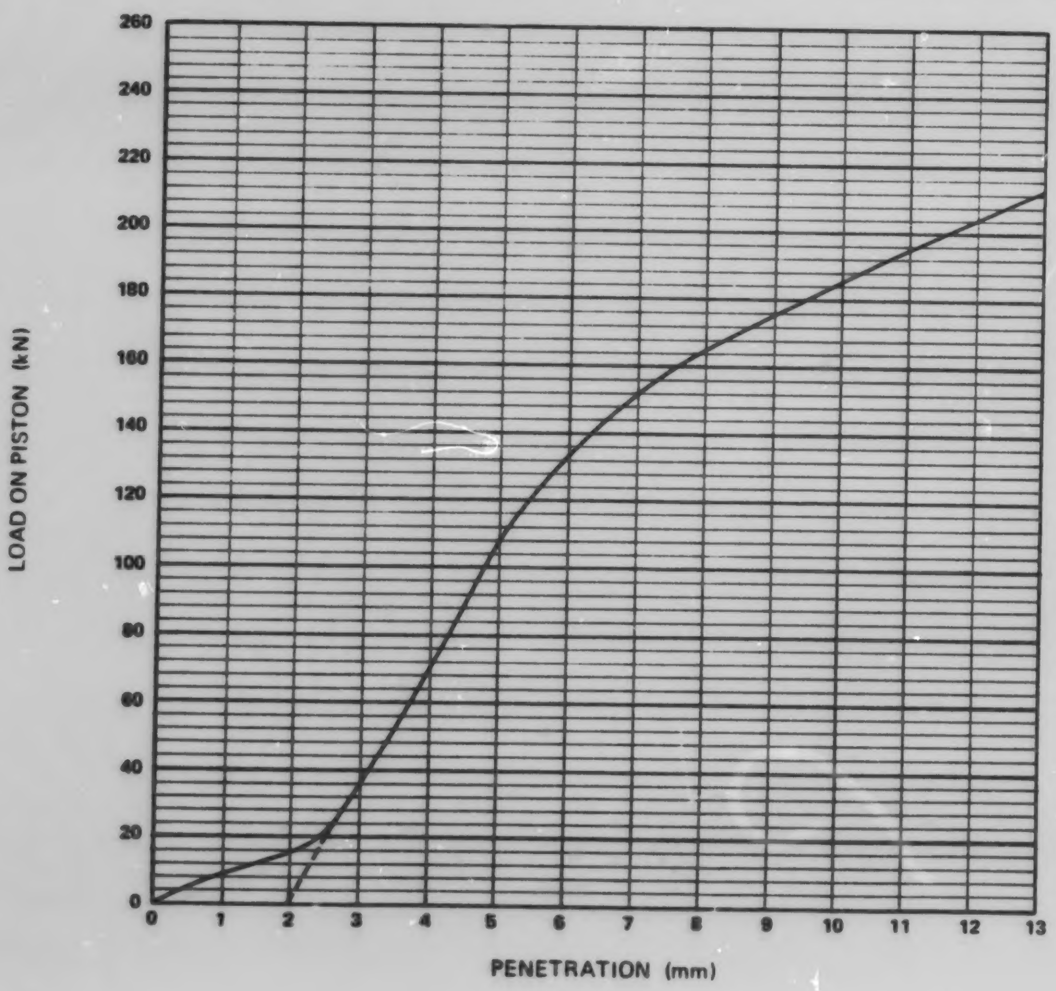
FLYASH %

California Bearing Ratio: 2.5 mm 660 %

CEMENT %

5.0 mm 760 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 100% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Bashaw

Sand 91%, Silt 7%, Clay 2%

Initial Dry Density: 1927 kg/m^3

Initial Moisture Content: 9.2%

Stabilizer Dosage: FUJIBETON 10 %

Final Moisture Content: 9.3%

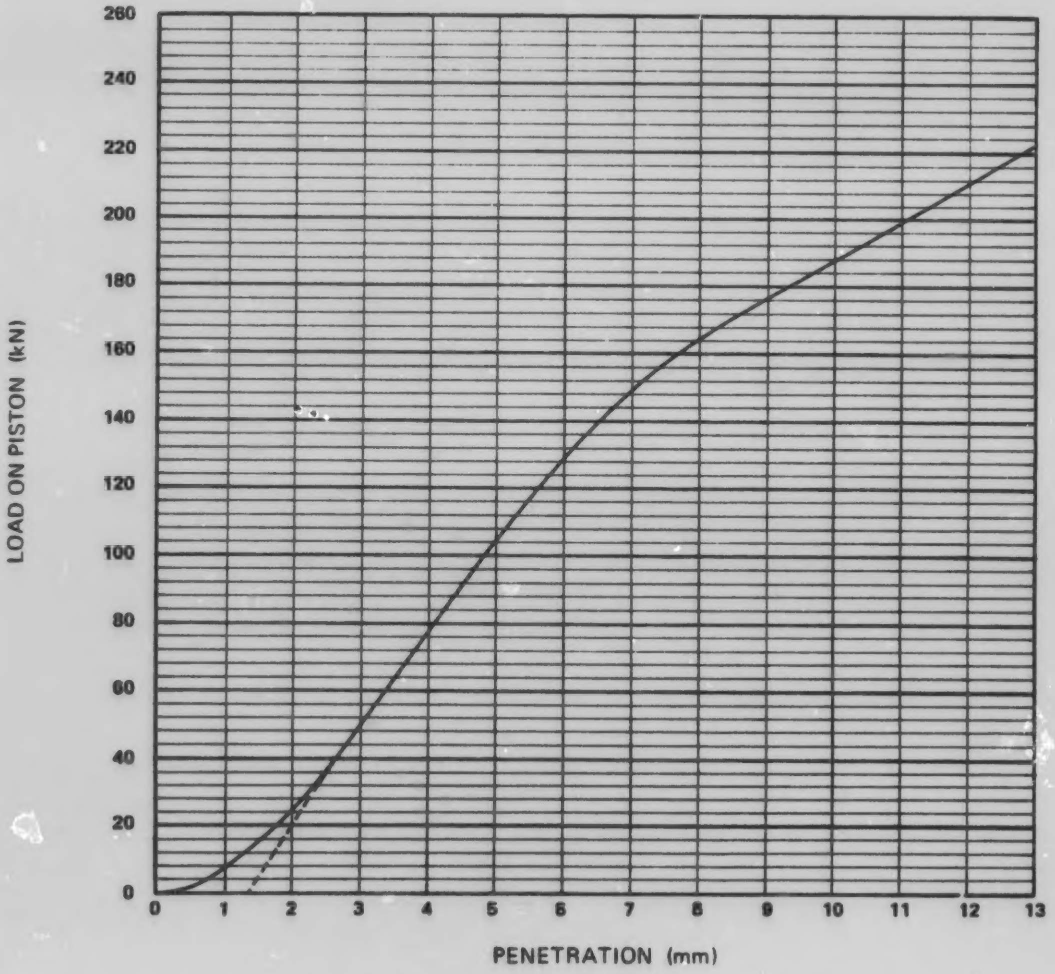
FLYASH %

California Bearing Ratio: 2.5 mm 562%

CEMENT %

5.0 mm 700%

Sample statically compacted to maximum dry density obtained during compaction test performed using 75% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Bashaw

Sand 91% , Silt 7% , Clay 2%

Initial Dry Density: 1905 kg/m^3

Initial Moisture Content: 8.9 %

Stabilizer Dosage: FUJIBETON ______ %

FLYASH 2 %

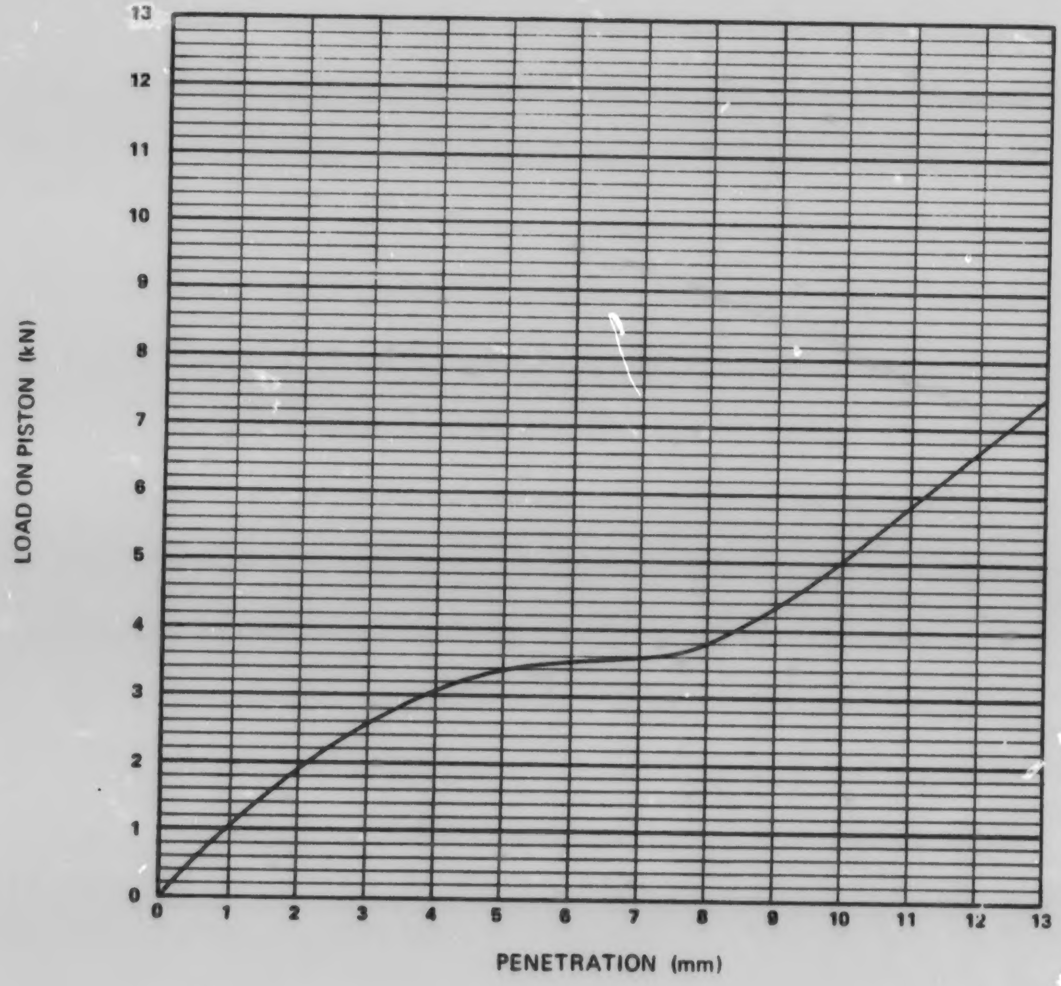
CEMENT ______ %

Final Moisture Content: 10.5 %

California Bearing Ratio: 2.5 mm 17 %

5.0 mm 17 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 100% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Bashaw

Sand 91%, Silt 7%, Clay 2%

Initial Dry Density: 1880.5 kg/m^3

Initial Moisture Content: 10.3 %

Stabilizer Dosage: FUJIBETON %

FLYASH 2 %

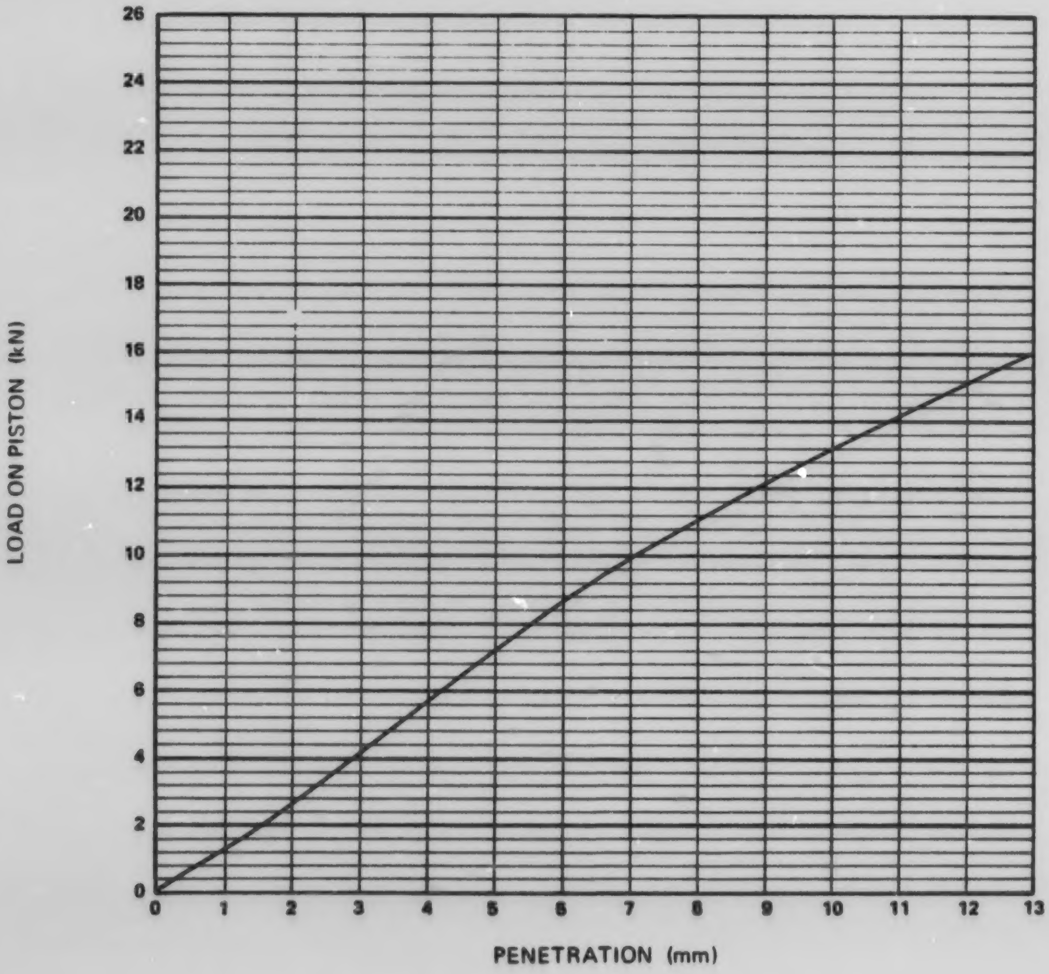
CEMENT %

Final Moisture Content: 11.2 %

California Bearing Ratio: 2.5 mm 17 %

5.0 mm 26 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 75% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Bashaw

Sand 91%, Silt 7%, Clay 2%

Initial Dry Density: 1897 kg/m^3

Initial Moisture Content: 9.0%

Stabilizer Dosage: FUJIBETON %

FLYASH 4 %

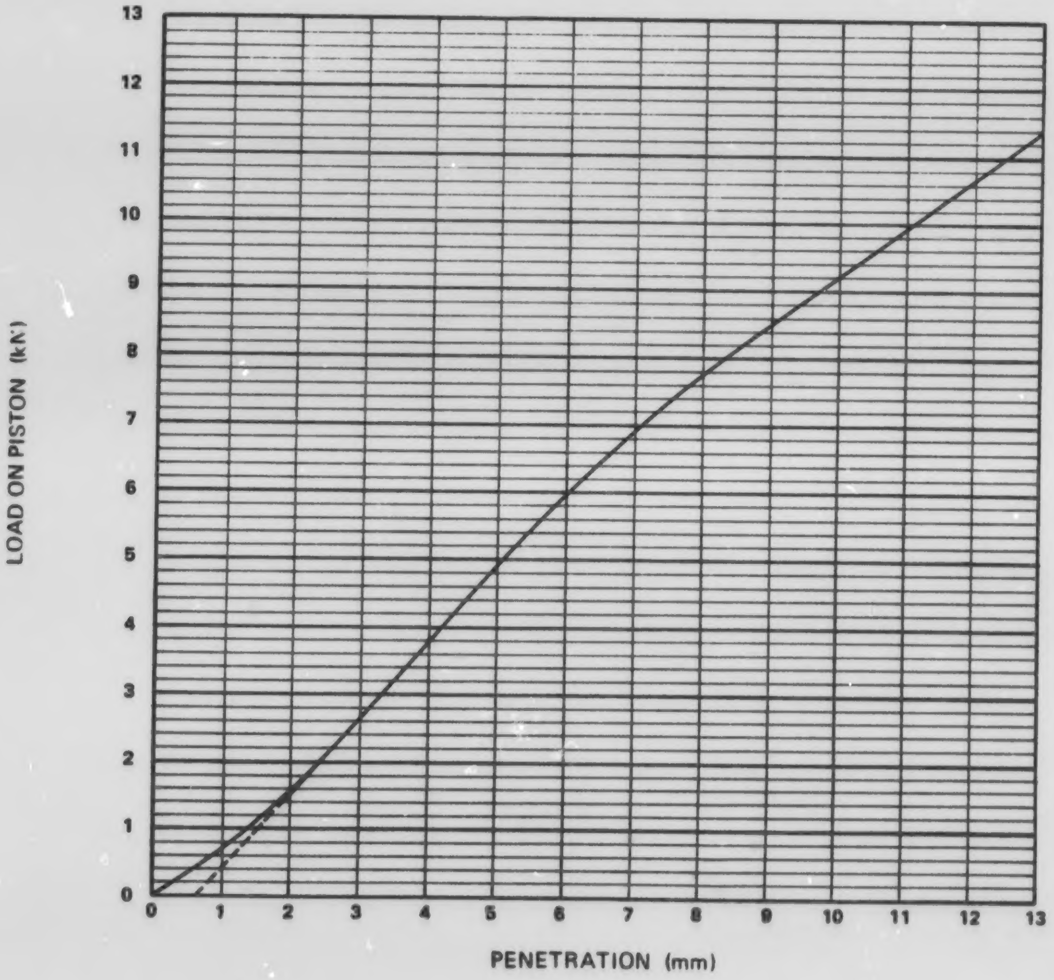
CEMENT %

Final Moisture Content: 12.9%

California Bearing Ratio: 2.5 mm 21%

5.0 mm 28%

Sample statically compacted to maximum dry density obtained during compaction test performed using 100% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Bashaw

Sand 91% , Silt 7% , Clay 2%

Initial Dry Density: 1886.9 kg/m^3

Initial Moisture Content: 9.1%

Stabilizer Dosage: FUJIBETON %

FLYASH 4 %

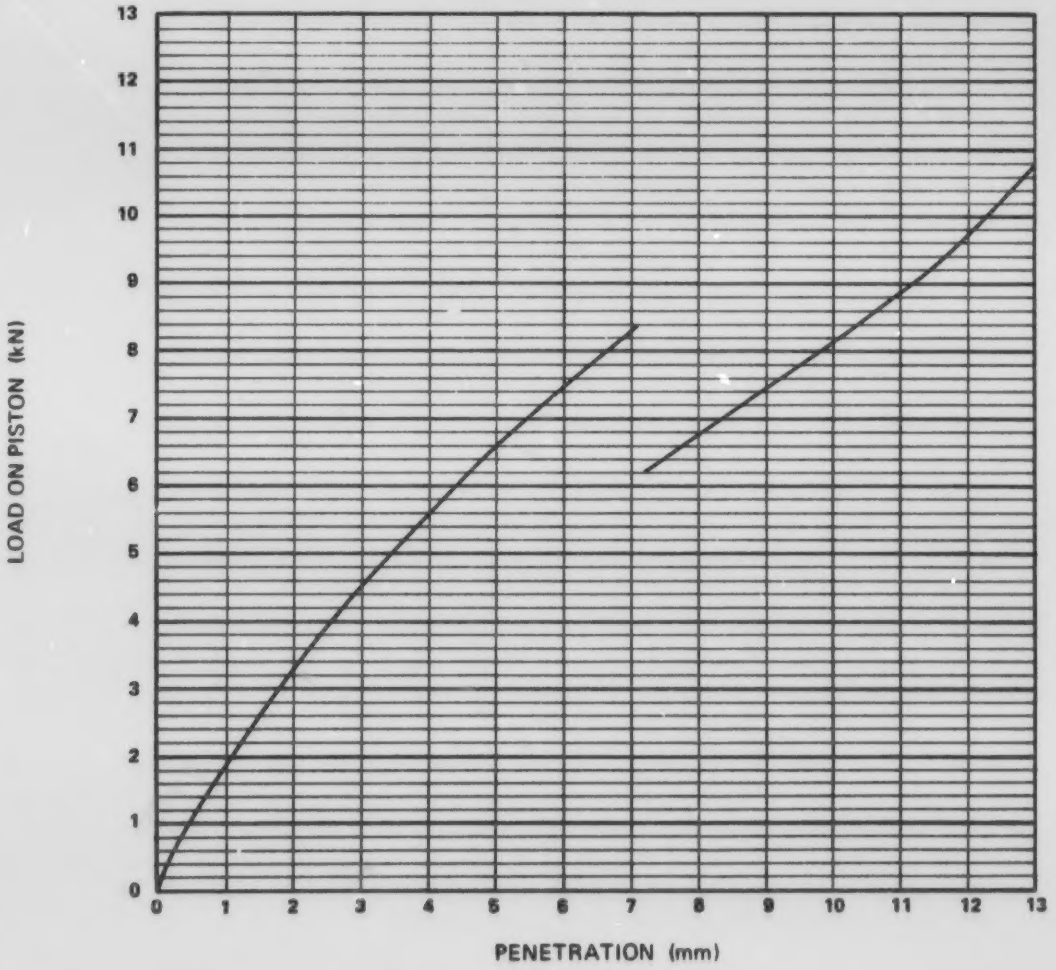
CEMENT %

Final Moisture Content: 10.9%

California Bearing Ratio: 2.5 mm 30%

5.0 mm 33%

Sample statically compacted to maximum dry density obtained during compaction test performed using 75% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.

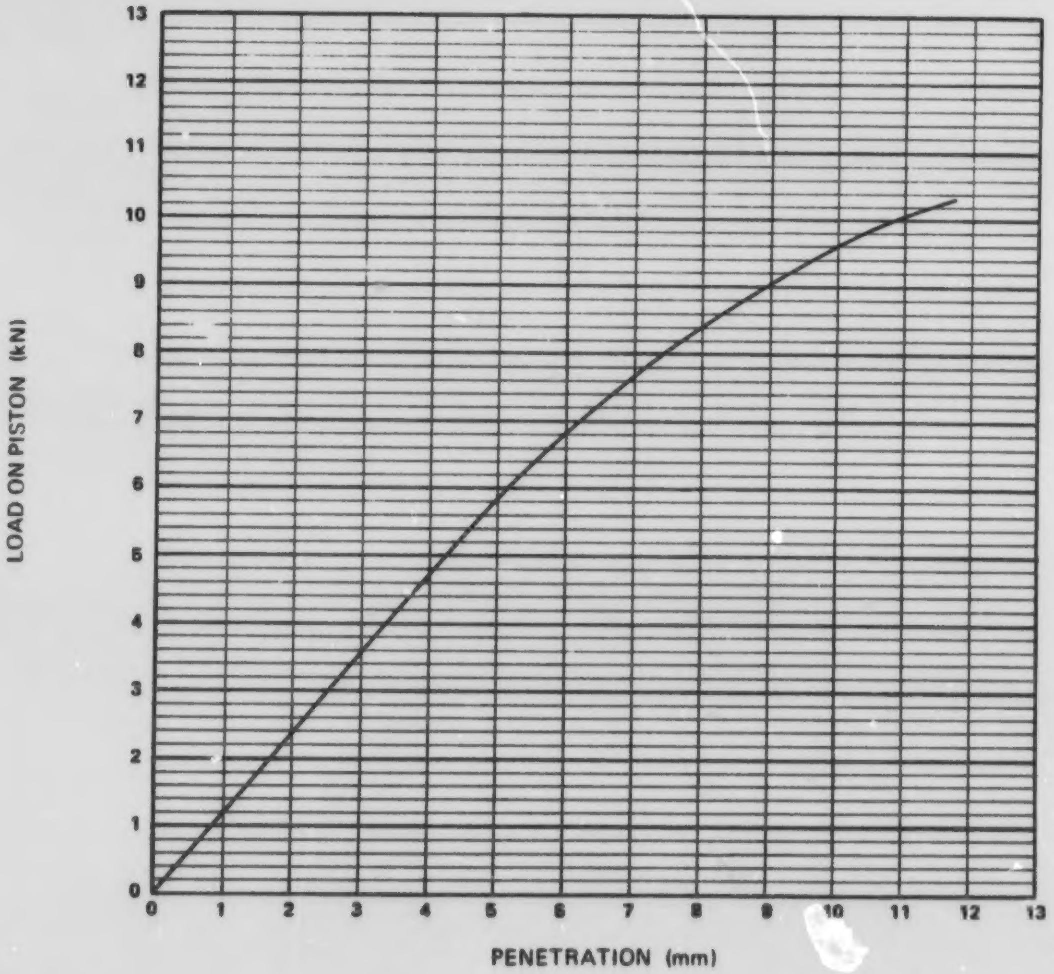


CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client:	TRANSPORT CANADA	Contract No.:	1 SD 83 - 00026
Project No.:	314 - 1264.02		
Sample:	Bashaw	Initial Dry Density:	1914 kg/m^3
	Sand 91%, Silt 7%, Clay 2%	Initial Moisture Content:	8.4%
Stabilizer Dosage: FUJIBETON	%	Final Moisture Content:	12.1%
FLYASH	6 %	California Bearing Ratio: 2.5 mm	22%
CEMENT	%	5.0 mm	30%

Sample statically compacted to maximum dry density obtained during compaction test performed using 100% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Bashaw

Sand 91%, Silt 7%, Clay 2%

Initial Dry Density: 1874.7 kg/m^3

Initial Moisture Content: 8.0%

Stabilizer Dosage: FUJIBETON ____ %

FLYASH 6 %

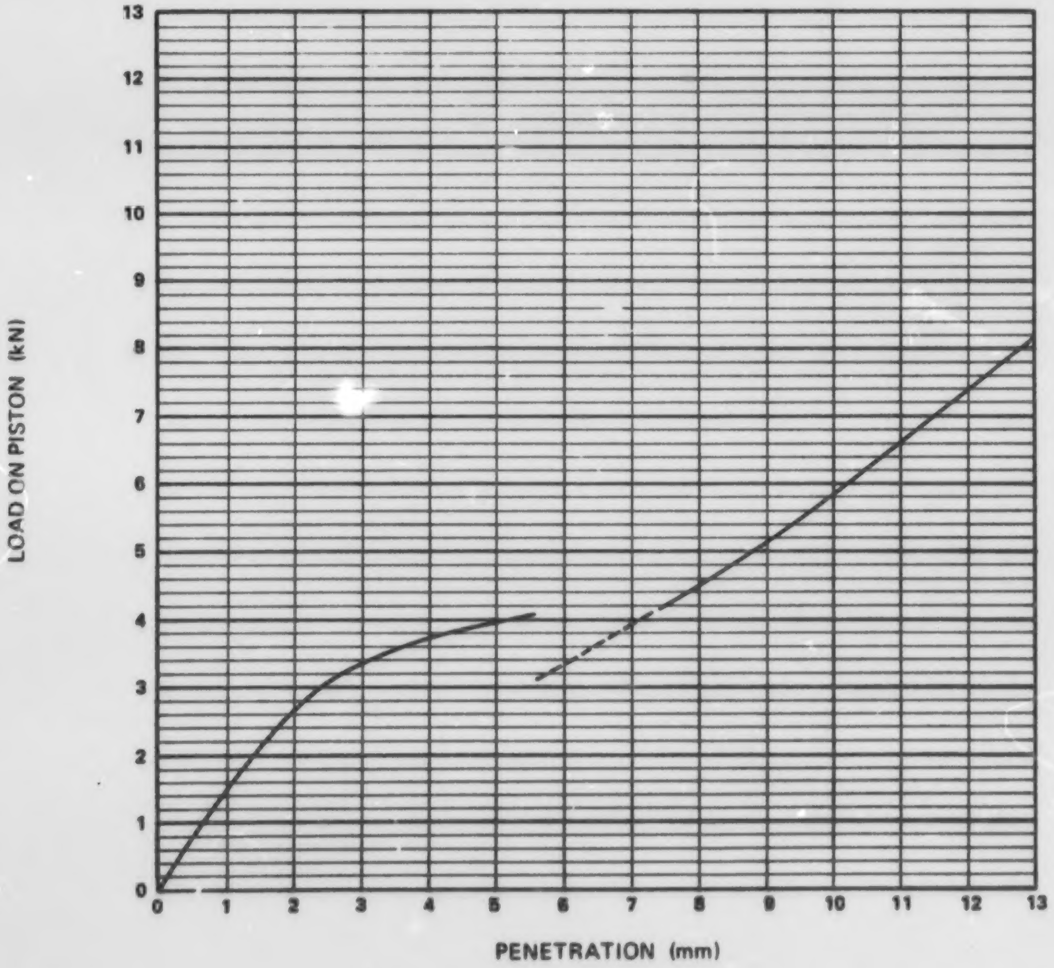
CEMENT ____ %

Final Moisture Content: 10.9%

California Bearing Ratio: 2.5 mm 24%

5.0 mm 20%

Sample statically compacted to maximum dry density obtained during compaction test performed using 75% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Bashaw

Sand 91%, Silt 7%, Clay 2%

Initial Dry Density: 1856.5 kg/m^3

Initial Moisture Content: 7.3 %

Final Moisture Content: 11.1 %

Stabilizer Dosage: FUJIBETON ____ %

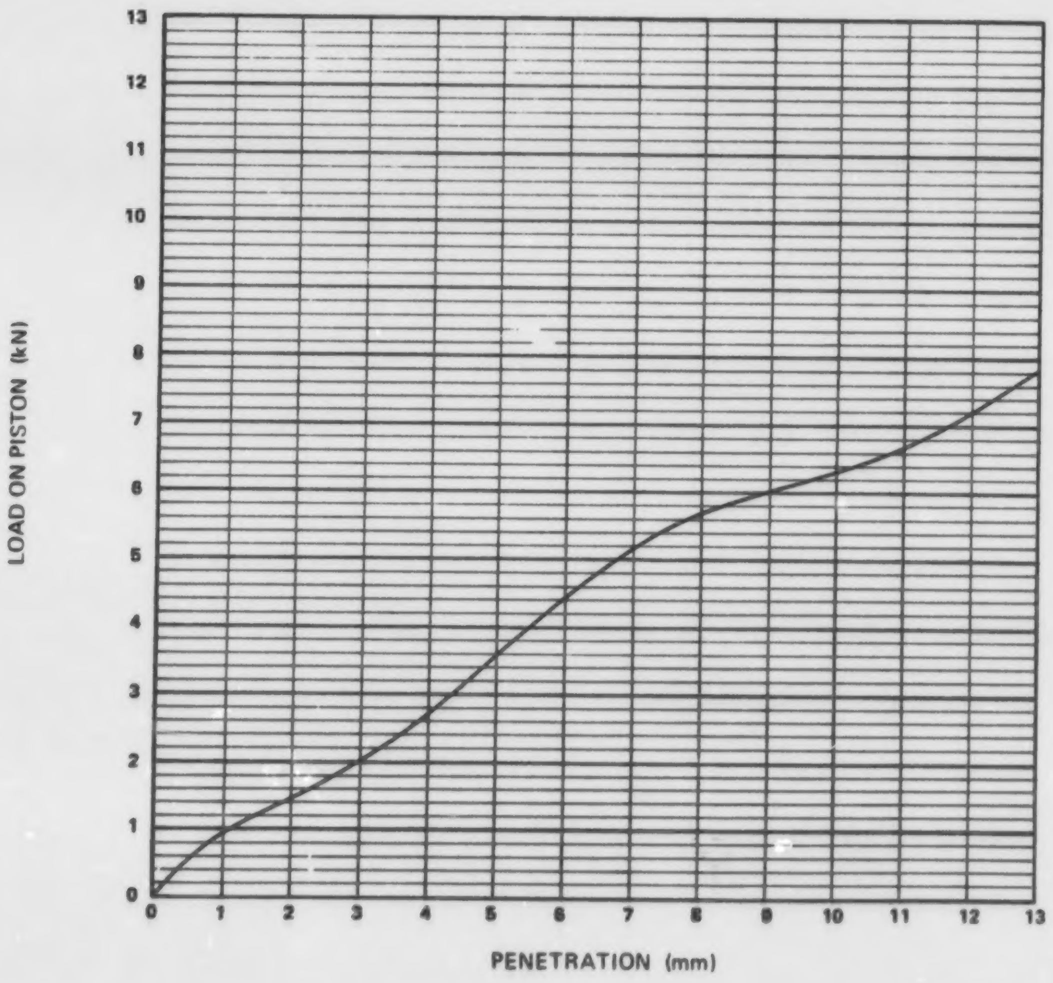
FLYASH 10 %

CEMENT ____ %

California Bearing Ratio: 2.5 mm 13 %

5.0 mm 18 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 100% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 · 00026

Project No.: 314 · 1264.02

Sample: Bashaw

Sand 91% , Silt 7% , Clay 2%

Initial Dry Density: 1871.7 kg/m^3

Initial Moisture Content: 9.2%

Stabilizer Dosage: FUJIBETON ____ %

FLYASH 10 %

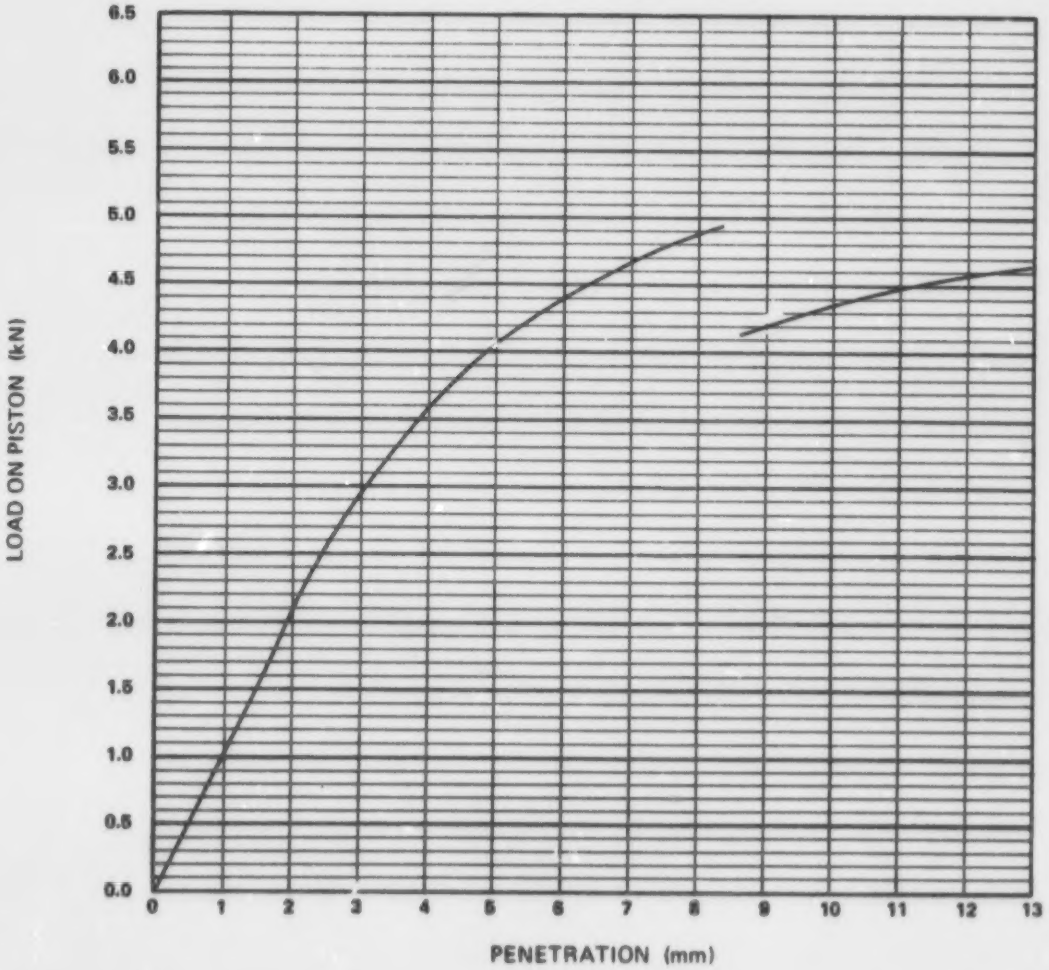
CEMENT ____ %

Final Moisture Content: 12.1%

California Bearing Ratio: 2.5 mm 20%

5.0 mm 20%

Sample statically compacted to maximum dry density obtained during compaction test performed using 75% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Bashaw

Sand 91% , Silt 7% , Clay 2%

Initial Dry Density: 1914 kg/m^3

Initial Moisture Content: 9.0 %

Stabilizer Dosage: FUJIBETON ____ %

Final Moisture Content: 12.5 %

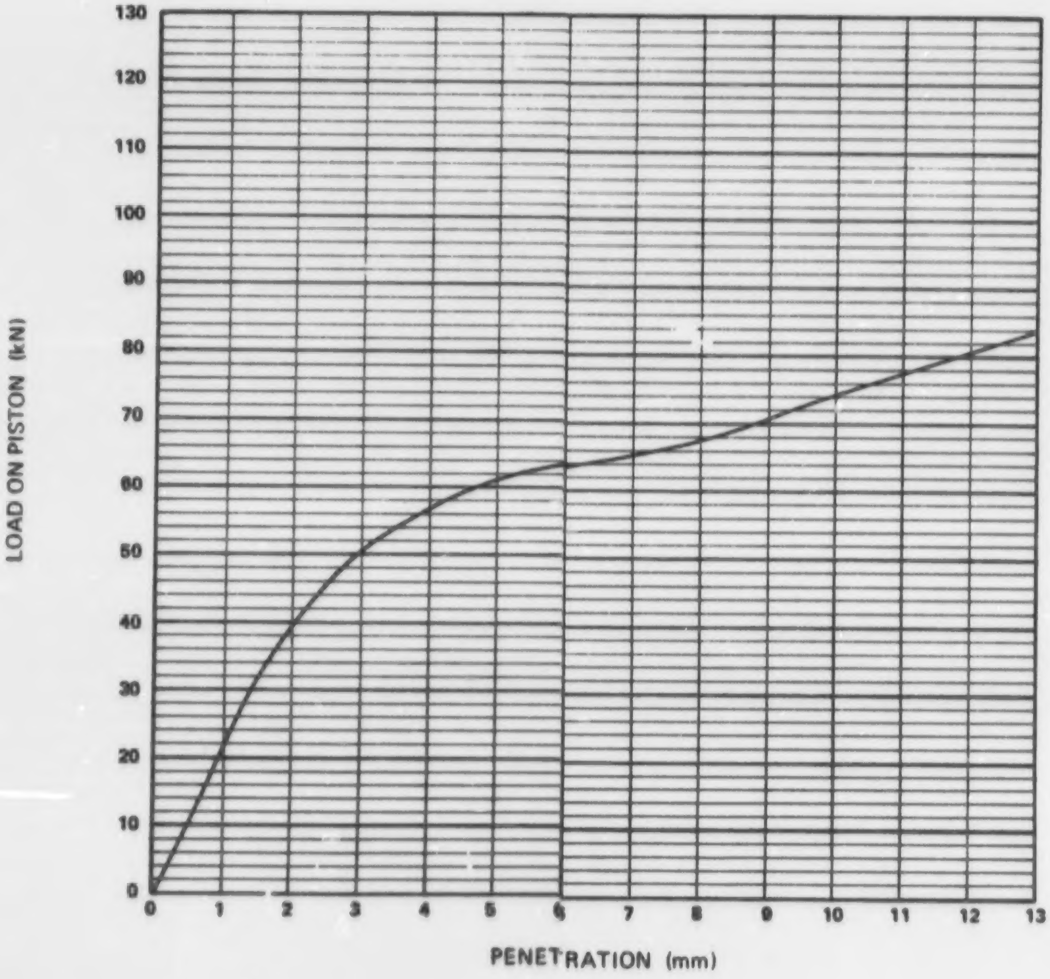
FLYASH 3 %

California Bearing Ratio: 2.5 mm 345 %

CEMENT 2 %

5.0 mm 310 %

Sample statically compacted to maximum dry density obtained during compaction test performed using 100% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



CALIFORNIA BEARING RATIO TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Sample: Bashaw

Sand 91%, Silt 7%, Clay 2%

Initial Dry Density: 1883.7 kg/m^3

Initial Moisture Content: 9.3%

Stabilizer Dosage: FUJIBETON ____ %

Final Moisture Content: 11.1%

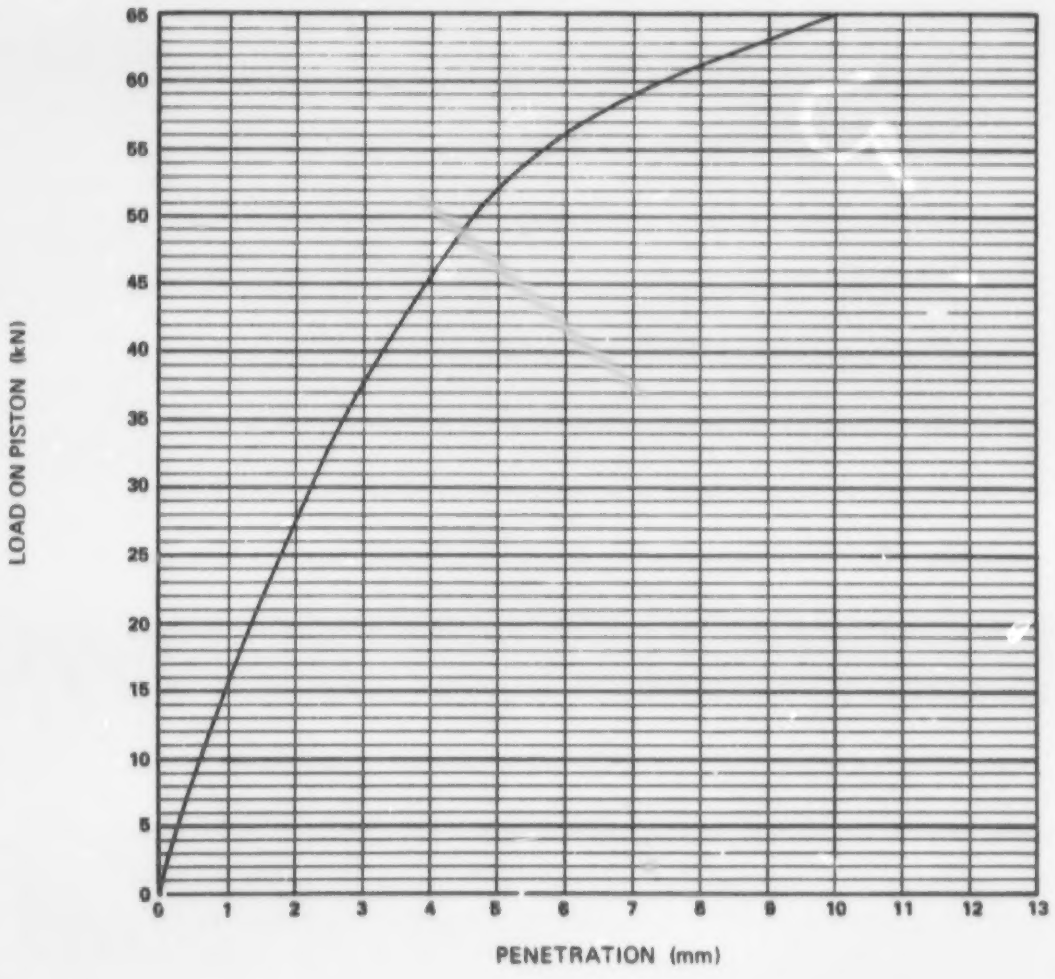
FLYASH 3 %

California Bearing Ratio: 2.5 mm 255%

CEMENT 2 %

5.0 mm 265%

Sample statically compacted to maximum dry density obtained during compaction test performed using 75% of standard compactive effort, then cured at 20°C and 100% humidity for 7 days.



WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1845 kg/m³

Sample: Bashaw

Sand 91 %, Silt 7 %, Clay 2 %

Design Optimum Moisture Content: % 9.5 %

Initial Dry Density: 1732 kg/m³

Initial Moisture Content: 9.5 %

Initial Volume: 944.5 cm³

Stabilizer Dosage: FUJIBETON 1 %

Volume After Curing: 939.2 cm³

FLYASH %

Final Moisture Content: 25.2 %

CEMENT %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 559 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm³)	VOLUME AFTER DRYING AND BRUSHING (cm³)	WEIGHT AFTER DRYING AND BRUSHING (g)
1	932.2	717.2	1137.5
2	750.0	363.9	584.3
3	357.9	159.3	257.3
4	164.9		
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during handling after fourth drying period

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1853 kg/m³

Sample: Bashaw

Design Optimum Moisture Content: 9.9 %

Sand 91 %, Silt 7 %, Clay 2 %

Initial Dry Density: 1837 kg/m³

Initial Moisture Content: 9.7 %

Initial Volume: 941.6 cm³

Stabilizer Dosage: FUJIBETON 1 %

Volume After Curing: 951.9 cm³

FLYASH %

Final Moisture Content: 12.1 %

CEMENT %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 559 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm³)	VOLUME AFTER DRYING AND BRUSHING (cm³)	WEIGHT AFTER DRYING AND BRUSHING (g)
1	932.6	745.7	1285.0
2	746.7	545.6	878.3
3	549.3	425.4	688.6
4	326.9		
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated after fourth inundation

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1872 kg/m3

Sample: Bashaw

Design Optimum Moisture Content:% 10.2 %

Sand 91 %, Silt 7 %, Clay 2 %

Initial Dry Density: 1783 kg/m3

Initial Moisture Content: 8.8 %

Initial Volume: 960.9 cm3

Stabilizer Dosage FUJIBETON 2 %

Volume After Curing: 965.2 cm3

FLYASH %

Final Moisture Content: --- %

CEMENT %

Stabilized Soil Loss: 73 %

Method of Sample Preparation: ASTM D 559 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm3)	VOLUME AFTER DRYING AND BRUSHING (cm3)	WEIGHT AFTER DRYING AND BRUSHING (g)
1	948.1	877.5	1498.2
2	952.9	781.6	1318.3
3	764.1	664.6	1136.7
4	694.2	636.0	1015.9
5	642.1	524.3	890.7
6	550.8	541.6	849.7
7	523.9	477.9	805.2
8	481.0	479.6	755.7
9	456.9	450.3	707.6
10	433.2	405.3	685.1
11	402.6	353.4	562.9
12	350.9	273.9	461.7

Remarks: Unconfined compressive strength after durability test determined as 0.08 MPa

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1855 kg/m3

Sample: Bashaw

Design Optimum Moisture Content:% 9.5 %

Sand 91 %, Silt 7 %, Clay 2 %

Initial Dry Density: 1836 kg/m3

Initial Moisture Content: 10.6 %

Initial Volume: 946.0 cm3

Stabilizer Dosage: FUJIBETON 2 %

Volume After Curing: 944.0 cm3

FLYASH %

Final Moisture Content: --- %

CEMENT %

Stabilized Soil Loss: 52 %

Method of Sample Preparation: ASTM D 559 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm3)	VOLUME AFTER DRYING AND BRUSHING (cm3)	WEIGHT AFTER DRYING AND BRUSHING (g)
1	930.9	857.6	1554.3
2	857.8	755.4	1407.0
3	784.3	712.0	1287.5
4	708.4	655.9	1192.5
5	654.5	636.1	1111.9
6	628.7	616.3	1088.5
7	624.5	617.7	1063.0
8	578.4	569.3	1032.0
9	571.5	549.5	997.5
10	561.8	563.2	981.7
11	556.0	483.1	884.5
12	497.4	478.0	833.1

Remarks: Unconfined compressive strength after durability test determined as 0.33 MPa

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 · 00026

Project No.: 314 · 1264.02

Design Maximum Dry Density: 1920 kg/m^3

Sample: Bashaw

Sand 91 %, Silt 7 %, Clay 2 %

Design Optimum Moisture Content: 8.6 %

Initial Dry Density: 1806 kg m^3

Initial Moisture Content: 8.4 %

Initial Volume: 960.0 cm^3

Stabilizer Dosage: FUJIBETON 4 %

FLYASH %

CEMENT %

Volume After Curing: 1017.0 cm^3

Final Moisture Content: --- %

Stabilized Soil Loss: 21 %

Method of Sample Preparation: ASTM D 559 · 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm^3)	VOLUME AFTER DRYING AND BRUSHING (cm^3)	WEIGHT AFTER DRYING AND BRUSHING (g)
1	952.9	937.8	1650.0
2	943.8	924.6	1612.4
3	892.8	903.9	1569.3
4	903.4	938.2	1543.6
5	884.4	892.5	1513.3
6	931.3	908.7	1505.0
7	904.6	889.6	1490.5
8	891.0	850.2	1480.5
9	866.1	877.8	1463.1
10	879.3	863.6	1453.5
11	846.9	824.3	1411.4
12	801.3	794.9	1366.0

Remarks: Unconfined compressive strength after durability test determined as 0.80 MPa

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Project No.: 314 - 1264.02

Sample: Bashaw

Sand 91 %, Silt 7 %, Clay 2 %

Stabilizer Dosage: FUJIBETON 4 %

FLYASH %

CEMENT %

Contract No.: 1 SD 83 - 00026

Design Maximum Dry Density: 1855 kg/m3

Design Optimum Moisture Content:% 9.0 %

Initial Dry Density: 1832 kg/m3

Initial Moisture Content: 8.0 %

Initial Volume: 943.0 cm3

Volume After Curing: 956.5 cm3

Final Moisture Content: --- %

Stabilized Soil Loss: 22 %

Method of Sample Preparation: ASTM D 559 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm^3)	VOLUME AFTER DRYING AND BRUSHING (cm^3)	WEIGHT AFTER DRYING AND BRUSHING (g)
1	939.2	907.8	1648.6
2	930.8	867.6	1586.9
3	877.1	875.8	1539.5
4	837.2	853.8	1507.9
5	829.4	852.5	1476.8
6	864.8	854.8	1467.3
7	854.4	837.5	1449.6
8	809.1	808.4	1442.4
9	810.6	837.1	1427.2
10	835.9	804.4	1422.7
11	803.3	785.2	1386.0
12	791.7	749.2	1359.1

Remarks: Unconfined compressive strength after durability test determined as 1.5 MPa

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1920 kg/m3

Sample: Bashaw

Design Optimum Moisture Content:% 9.6 %

Sand 91 %, Silt 7 %, Clay 2 %

Initial Dry Density: 1827 kg/m3

Initial Moisture Content: 8.3 %

Initial Volume: 958.4 cm3

Stabilizer Dosage: FUJIBETON 6 %

Volume After Curing: 977.8 cm3

FLYASH %

Final Moisture Content: --- %

CEMENT %

Stabilized Soil Loss: 16 %

Method of Sample Preparation: ASTM D 559 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm³)	VOLUME AFTER DRYING AND BRUSHING (cm³)	WEIGHT AFTER DRYING AND BRUSHING (g)
1	945.3	919.5	1653.3
2	958.2	936.2	1645.0
3	942.0	919.6	1603.1
4	917.3	918.2	1579.6
5	914.2	914.8	1559.7
6	928.3	934.3	1555.2
7	938.3	932.0	1547.6
8	908.3	937.1	1542.3
9	918.0	909.0	1534.1
10	911.1	907.1	1531.1
11	922.1	906.8	1507.1
12	920.3	906.9	1474.3

Remarks: Unconfined compressive strength after durability determined as 0.95 MPa

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1870 kg/m^3

Sample: Bashaw

Design Optimum Moisture Content:% 11 %

Sand 91 %, Silt 7 %, Clay 2 %

Initial Dry Density: 1876 kg/m^3

Initial Moisture Content: 8.2 %

Initial Volume: 947.9 cm^3

Stabilizer Dosage: FUJIBETON 6 %

Volume After Curing: 951.7 cm^3

FLYASH %

Final Moisture Content: --- %

CEMENT %

Stabilized Soil Loss: 13 %

Method of Sample Preparation: ASTM D 559 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm^3)	VOLUME AFTER DRYING AND BRUSHING (cm^3)	WEIGHT AFTER DRYING AND BRUSHING (g)
1	952.4	915.9	1710.2
2	925.7	912.1	1694.9
3	922.2	925.7	1670.3
4	917.5	911.5	1651.2
5	941.8	914.9	1635.4
6	931.8	933.7	1632.0
7	895.3	928.8	1621.1
8	894.1	891.3	1619.1
9	883.9	903.0	1609.8
10	893.1	897.0	1607.1
11	895.1	883.6	1586.7
12	887.6	880.1	1562.4

Remarks: Unconfined compression strength after durability test determined as 2.0 MPa

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 · 00026

Project No.: 314 · 1264.02

Design Maximum Dry Density: 1950 kg/m^3

Sample: Bashaw

Design Optimum Moisture Content:% 8.7 %

Sand 91 %, Silt 7 %, Clay 2 %

Initial Dry Density: 1842 kg/m^3

Initial Moisture Content: 8.1 %

Initial Volume: 966.9 cm^3

Stabilize Dosage: FUJIBETON 10 %

Volume After Curing: 973.4 cm^3

FLYASH %

Final Moisture Content: --- %

CEMENT %

Stabilized Soil Loss: 5.0 %

Method of Sample Preparation: ASTM D 559 · 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm^3)	VOLUME AFTER DRYING AND BRUSHING (cm^3)	WEIGHT AFTER DRYING AND BRUSHING (g)
1	954.7	940.2	1722.6
2	978.7	943.7	1726.2
3	984.1	949.4	1709.8
4	922.9	921.0	1704.1
5	922.6	925.8	1706.3
6	957.0	942.9	1707.1
7	952.4	958.1	1700.6
8	939.4	963.4	1703.0
9	959.4	952.0	1701.3
10	956.3	954.5	1700.7
11	953.1	950.0	1697.8
12	953.5	953.4	1693.9

Remarks: Unconfined compressive strength after durability test determined as 4.3 MPa

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Project No.: 314 - 1264.02

Sample: Bashaw

Sand 91 %, Silt 7 %, Clay 2 %

Stabilizer Dosage: FUJIBETON 10 %

FLYASH %

CEMENT %

Contract No.: 1 SD 83 - 00026

Design Maximum Dry Density: 1895 kg/m3

Design Optimum Moisture Content:% 9.7 %

Initial Dry Density: 1865 kg/m3

Initial Moisture Content: 7.3 %

Initial Volume: 942.2 cm3

Volume After Curing: 962.4 cm3

Final Moisture Content: --- %

Stabilized Soil Loss: 6.1 %

Method of Sample Preparation: ASTM D 559 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm3)	VOLUME AFTER DRYING AND BRUSHING (cm3)	WEIGHT AFTER DRYING AND BRUSHING (g)
1	949.8	930.4	1732.9
2	948.5	947.0	1732.0
3	939.3	931.4	1718.2
4	921.7	907.5	1712.4
5	912.4	913.2	1712.8
6	934.7	935.7	1711.7
7	947.0	948.3	1705.3
8	954.0	923.7	1710.2
9	933.2	932.7	1704.5
10	944.8	946.6	1704.1
11	942.0	936.1	1698.5
12	925.5	921.7	1693.4

Remarks: Unconfined compressive strength after durability test determined as 6.6 MPa

EBA Engineering Consultants Ltd.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 · 00026

Project No.: 314 · 1264.02

Design Maximum Dry Density: 1890 kg/m3

Sample: Bashaw

Design Optimum Moisture Content:%: 9.0 %

Sand 91 %, Silt 7 %, Clay 2 %

Initial Dry Density: 1774 kg/m3

Initial Moisture Content: 9.1 %

Initial Volume: 943.6 cm3

Stabilizer Dosage: FUJIBETON ______ %

Volume After Curing: --- cm3

FLYASH 2 %

Final Moisture Content: 20.1 %

CEMENT ______ %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 559 · 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm3)	VOLUME AFTER DRYING AND BRUSHING (cm3)	WEIGHT AFTER DRYING AND BRUSHING (g)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during initial curing period

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client:	TRANSPORT CANADA	Contract No.:	1 SD 83 - 00026
Project No.:	314 - 1264.02	Design Maximum Dry Density:	1845 kg/m³
Sample:	Bashaw	Design Optimum Moisture Content:%	10.5 %
	Sand 91 %, Silt 7 %, Clay 2 %	Initial Dry Density:	1845 kg/m³
		Initial Moisture Content:	9.2 %
		Initial Volume:	945.8 cm³
Stabilizer Dosage: FUJIBETON	%	Volume After Curing:	--- cm³
FLYASH	2 %	Final Moisture Content:	15.1 %
CEMENT	%	Stabilized Soil Loss:	100 %

Method of Sample Preparation: ASTM D 559 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm³)	VOLUME AFTER DRYING AND BRUSHING (cm³)	WEIGHT AFTER DRYING AND BRUSHING (g)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during initial curing period

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA	Contract No.: 1 SD 83 - 00026
Project No.: 314 - 1264.02	Design Maximum Dry Density: 1890 kg/m³
Sample: Bashaw	Design Optimum Moisture Content:% 9.4 %
Sand 91 %, Silt 7 %, Clay 2 %	Initial Dry Density: 1772 kg/m³
	Initial Moisture Content: 9.6 %
	Initial Volume: 949.3 cm³
Stabilizer Dosage: FUJIBETON %	Volume After Curing: --- cm³
FLYASH 4 %	Final Moisture Content: 15.7 %
CEMENT %	Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 559 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm³)	VOLUME AFTER DRYING AND BRUSHING (cm³)	WEIGHT AFTER DRYING AND BRUSHING (g)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during initial curing period

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1890 kg/m³

Sample: Bashaw

Design Optimum Moisture Content:% 10.1 %

Sand 91 %, Silt 7 %, Clay 2 %

Initial Dry Density: 1891 kg/m³

Initial Moisture Content: 8.5 %

Initial Volume: 938.9 cm³

Stabilizer Dosage: FUJIBETON ____ %

Volume After Curing: --- cm³

FLYASH 4 %

Final Moisture Content: 17.5 %

CEMENT ____ %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 559 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm³)	VOLUME AFTER DRYING AND BRUSHING (cm³)	WEIGHT AFTER DRYING AND BRUSHING (g)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during initial curing period

EBA Engineering Consultants Ltd.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1927 kg/m³

Sample: Bashaw

Design Optimum Moisture Content:% 8.5 %

Sand 91 %, Silt 7 %, Clay 2 %

Initial Dry Density: 1824 kg/m³

Initial Moisture Content: 7.7 %

Initial Volume: 960.4 cm³

Stabilizer Dosage: FUJIBETON %

Volume After Curing: 917.5 cm³

FLYASH 6 %

Final Moisture Content: 22.8 %

CEMENT %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 559 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm³)	VOLUME AFTER DRYING AND BRUSHING (cm³)	WEIGHT AFTER DRYING AND BRUSHING (g)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during first inundation

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83-00026

Project No.: 314-1264.02

Design Maximum Dry Density: 1900 kg/m³

Sample: Bashaw

Design Optimum Moisture Content %: 8.7 %

Sand 91 %, Silt 7 %, Clay 2 %

Initial Dry Density: 1911 kg/m³

Initial Moisture Content: 8.2 %

Initial Volume: 941.0 cm³

Stabilizer Dosage FUJIBETON ______ %

Volume After Curing: --- cm³

FLYASH 6 %

Final Moisture Content: 13.2 %

CEMENT ______ %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 559-57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA

CYCLE	VOLUME AFTER SOAKING (cm³)	VOLUME AFTER DRYING AND BRUSHING (cm³)	WEIGHT AFTER DRYING AND BRUSHING (g)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during initial curing period

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 · 00026

Project No.: 314 · 1264.02

Design Maximum Dry Density: 1945 kg/m3

Sample: Bashaw

Design Optimum Moisture Content:% 8.4 %

Sand 91 %, Silt 7 %, Clay 2 %

Initial Dry Density: 1874 kg m3

Initial Moisture Content: 7.9 %

Initial Volume: 958.7 cm3

Stabilizer Dosage FUJIBETON %

Volume After Curing: 958.5 cm3

FLYASH 10 %

Final Moisture Content: 16.2 %

CEMENT %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 559 · 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm3)	VOLUME AFTER DRYING AND BRUSHING (cm3)	WEIGHT AFTER DRYING AND BRUSHING (g)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during first inundation

EBA Engineering Consultants Ltd.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Project No.: 314 - 1264.02

Sample: Bashaw

Sand 91 %, Silt 7 %, Clay 2 %

Stabilizer Dosage: FUJIBETON %

FLYASH 10 %

CEMENT %

Contract No.: 1 SD 83 - 00026

Design Maximum Dry Density: 1909 kg/m3

Design Optimum Moisture Content: % 9.1 %

Initial Dry Density: 1938 kg/m3

Initial Moisture Content: 9.3 %

Initial Volume: 939.5 cm3

Volume After Curing: --- cm3

Final Moisture Content: 12.4 %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 559 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm3)	VOLUME AFTER DRYING AND BRUSHING (cm3)	WEIGHT AFTER DRYING AND BRUSHING (g)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Remarks: Sample disintegrated during initial curing period

EBA Engineering Consultants Ltd.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1910 kg/m^3

Sample: Bashaw

Design Optimum Moisture Content: % 9.0 %

Sand 91 %, Silt 7 %, Clay 2 %

Initial Dry Density: 1763 kg/m^3

Initial Moisture Content: 8.5 %

Initial Volume: 931.9 cm^3

Stabilizer Dosage: FUJIBETON ____ %

Volume After Curing: 943.4 cm^3

FLYASH 3 %

Final Moisture Content: --- %

CEMENT 2 %

Stabilized Soil Loss: 29 %

Method of Sample Preparation: ASTM D 559 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm^3)	VOLUME AFTER DRYING AND BRUSHING (cm^3)	WEIGHT AFTER DRYING AND BRUSHING (g)
1	918.2	889.6	1579.2
2	912.1	849.8	1512.6
3	888.4	818.6	1454.0
4	809.1	813.3	1404.3
5	818.4	848.3	1362.7
6	862.2	807.6	1351.3
7	762.0	767.5	1330.7
8	724.9	833.8	1315.1
9	836.3	745.3	1295.3
10	719.5	717.4	1284.8
11	717.8	689.0	1249.0
12	674.3	667.6	1200.9

Remarks: Unconfined compressive strength after durability test determined as 5.3 MPa

EBA Engineering Consultants Ltd.

WET/DRY DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Co[illegible] No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1888 kg/m³

Sample: Bashaw

Design Optimum Moisture Content:% 9.5 %

Sand 91 %, Silt 7 %, Clay 2 %

Initial Dry Density: 1858 kg/m³

Initial Moisture Content: 8.3 %

Initial Volume: 941.4 cm³

Stabilizer Dosage: FUJIBETON ______ %

Volume After Curing: 952.5 cm³

FLYASH 3 %

Final Moisture Content: --- %

CEMENT 2 %

Stabilized Soil Loss: 21 %

Method of Sample Preparation: ASTM D 559 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER SOAKING (cm³)	VOLUME AFTER DRYING AND BRUSHING (cm³)	WEIGHT AFTER DRYING AND BRUSHING (g)
1	934.8	876.0	1595.9
2	922.3	834.4	1529.4
3	864.5	830.7	1464.8
4	830.6	793.6	1427.8
5	810.3	820.6	1386.2
6	804.5	779.7	1375.4
7	758.4	800.5	1362.1
8	779.7	743.5	1346.5
9	759.7	752.1	1326.1
10	752.4	773.2	1316.5
11	771.3	729.1	1271.7
12	715.5	708.6	1239.5

Remarks: Unconfined compressive strength after durability test determined as 1.1 MPa

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client:	TRANSPORT CANADA	Contract No.:	1 SD 83 - 00026
Project No.:	314 - 1264.02	Design Maximum Dry Density:	1845 kg/m^3
Sample:	Bashaw	Design Optimum Moisture Content:	9.5 %
	Sand 91 %, Silt 7 %, Clay 2 %	Initial Dry Density:	1701 kg/m^3
		Initial Moisture Content	11.4 %
		Initial Volume:	935.0 cm^3
Stabilizer Dosage: FUJIBETON	1 %	Volume After Curing:	--- cm^3
FLYASH	%	Final Moisture Content:	14.3 %
CEMENT	%	Stabilized Soil Loss:	100 %

Method of Sample Preparation: ASTM D 560 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm^3)	WEIGHT AFTER THAWING AND BRUSHING (g)
1	946.1	1845.1
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated during second thawing period

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Project No.: 314 - 1264.02

Sample: Bashaw
Sand 91 %, Silt 7 %, Clay 2 %

Stabilizer Dosage: FUJIBETON 1 %
FLYASH %
CEMENT %

Contract No.: 1 SD 83 - 00026

Design Maximum Dry Density: 1853 kg/m³

Design Optimum Moisture Content: 9.9 %

Initial Dry Density: 1853 kg/m³

Initial Moisture Content: 8.9 %

Initial Volume: 941.7 cm³

Volume After Curing: --- cm³

Final Moisture Content: --- %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 560 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm³)	WEIGHT AFTER THAWING AND BRUSHING (g)
1	769.9	1516.3
2	547.6	1131.8
3	415.5	850.9
4	289.2	578.2
5		
6		
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated during fifth thawing period

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Project No.: 314 - 1264.02

Sample: Bashaw

Sand 91 %, Silt 7 %, Clay 2 %

Stabilizer Dosage: FUJIBETON 2 %

FLYASH %

CEMENT %

Contract No.: 1 SD 83 - 00026

Design Maximum Dry Density: 1872 kg/m3

Design Optimum Moisture Content: 10.2 %

Initial Dry Density: 1778 kg/m3

Initial Moisture Content: 9.0 %

Initial Volume: 963.3 cm3

Volume After Curing: --- cm3

Final Moisture Content: 16.8 %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 560 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm3)	WEIGHT AFTER THAWING AND BRUSHING (g)
1	958.8	1914.9
2	929.0	1779.2
3	775.7	1541.2
4	657.1	1305.9
5	564.9	1054.6
6	437.6	838.0
7	385.5	705.0
8	251.8	499.9
9	240.4	446.9
10	154.6	284.8
11		
12		

Remarks: Sample disintegrated during eleventh thawing period

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1855 kg/m³

Sample: Bashaw

Design Optimum Moisture Content: 9.5 %

Sand 91 %, Silt 7 %, Clay 2 %

Initial Dry Density: 1847 kg/m³

Initial Moisture Content: 9.4 %

Initial Volume: 952.3 cm³

Stabilizer Dosage: FUJIBETON 2 %

Volume After Curing: --- cm³

FLYASH %

Final Moisture Content: 12.5 %

CEMENT %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 560 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm³)	WEIGHT AFTER THAWING AND BRUSHING (g)
1	1201.5	1879.4
2	887.3	1762.8
3	791.4	1598.7
4	746.3	1483.8
5	690.8	1318.0
6	417.5	1169.5
7	541.7	1074.9
8	453.3	925.5
9	445.7	891.5
10	373.6	787.3
11		
12		

Remarks: Sample disintegrated during eleventh thawing period

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Project No.: 314 - 1264.02

Sample: Bashaw

Sand 91 %, Silt 7 %, Clay 2 %

Stabilizer Dosage: FUJIBETON 4 %

FLYASH %

CEMENT %

Contract No.: 1 SD 83 - 00026

Design Maximum Dry Density: 1920 kg/m^3

Design Optimum Moisture Content: 8.6 %

Initial Dry Density: 1814 kg/m^3

Initial Moisture Content: 7.9 %

Initial Volume: 971.4 cm^3

Volume After Curing: --- cm^3

Final Moisture Content: 15.2 %

Stabilized Soil Loss: 45 %

Method of Sample Preparation: ASTM D 560 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm^3)	WEIGHT AFTER THAWING AND BRUSHING (g)
1	984.5	1935.6
2	958.4	1894.4
3	933.2	1866.3
4	936.0	1832.8
5	952.0	1778.9
6	858.9	1701.0
7	821.1	1594.7
8	792.6	1497.6
9	716.7	1456.5
10	711.0	1329.5
11	606.2	1214.1
12	549.8	1088.3

Remarks: Unconfined compressive strength after durability test determined as 0.16 MPa

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1855 kg/m3

Sample: Bashaw

Sand 91 %, Silt 7 %, Clay 2 %

Design Optimum Moisture Content: 9.0 %

Initial Dry Density: 1836 kg/m3

Initial Moisture Content: 7.9 %

Initial Volume: 946.6 cm3

Stabilizer Dosage: FUJIBETON 4 %

FLYASH %

CEMENT %

Volume After Curing: --- cm3

Final Moisture Content: 13.4 %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 560 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm3)	WEIGHT AFTER THAWING AND BRUSHING (g)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated during initial curing period

EBA Engineering Consultants Ltd.

eba

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Project No.: 314 - 1264.02

Sample: Bashaw

Sand 91 %, Silt 7 %, Clay 2 %

Stabilizer Dosage: FUJIBETON 6 %

FLYASH %

CEMENT %

Contract No.: 1 SD 83 - 00026

Design Maximum Dry Density: 1920 kg/m^3

Design Optimum Moisture Content: 9.6 %

Initial Dry Density: 1773 kg/m^3

Initial Moisture Content: 11.3 %

Initial Volume: 930.5 cm^3

Volume After Curing: --- cm^3

Final Moisture Content: 14.2 %

Stabilized Soil Loss: 18 %

Method of Sample Preparation: ASTM D 560 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm^3)	WEIGHT AFTER THAWING AND BRUSHING (g)
1	929.7	1907.5
2	949.1	1887.0
3	923.7	1877.8
4	926.5	1855.1
5	915.5	1826.3
6	898.9	1775.8
7	881.8	1763.7
8	855.6	1730.3
9	845.2	1729.9
10	852.9	1683.5
11	846.1	1643.0
12	802.1	1596.1

Remarks: Unconfined compressive strength after durability test determined as 0.70 MPa

EBA Engineering Consultants Ltd.

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1870 kg/m^3

Sample: Bashaw

Design Optimum Moisture Content: 11 %

Sand 91 %, Silt 7 %, Clay 2 %

Initial Dry Density: 1844 kg/m^3

Initial Moisture Content: 10.5 %

Initial Volume: 896.9 cm^3

Stabilizer Dosage: FUJIBETON 6 %

Volume After Curing: --- cm^3

FLYASH %

Final Moisture Content: 6.1 %

CEMENT %

Stabilized Soil Loss: 6.5 %

Method of Sample Preparation: ASTM D 560 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm^3)	WEIGHT AFTER THAWING AND BRUSHING (g)
1	949.1	1974.0
2	950.9	1945.2
3	935.0	1930.0
4	924.8	1911.2
5	943.0	1896.4
6	872.4	1862.4
7	932.5	1860.6
8	876.6	1836.8
9	890.7	1840.7
10	871.5	1808.1
11	865.2	1783.7
12	879.7	1752.7

Remarks: Unconfined compressive strength after durability test determined as 1.0 MPa

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Project No.: 314 - 1264.02

Sample: Bashaw

Sand 91 %, Silt 7 %, Clay 2 %

Stabilizer Dosage: FUJIBETON 10 %

FLYASH %

CEMENT %

Contract No.: 1 SD 83 - 00026

Design Maximum Dry Density: 1950 kg/m^3

Design Optimum Moisture Content: 8.7 %

Initial Dry Density: 1855 kg/m^3

Initial Moisture Content: 7.6 %

Initial Volume: 960.4 cm^3

Volume After Curing: --- cm^3

Final Moisture Content: 13.6 %

Stabilized Soil Loss: 4.3 %

Method of Sample Preparation: ASTM D 560 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm^3)	WEIGHT AFTER THAWING AND BRUSHING (g)
1	977.8	1930.0
2	960.8	1939.3
3	949.4	1974.5
4	926.4	1980.8
5	919.0	1975.7
6	953.0	1963.2
7	963.0	1967.9
8	958.1	1964.6
9	962.1	1964.9
10	963.6	1965.0
11	947.7	1958.5
12	931.6	1950.8

Remarks: Unconfined compressive strength after durability test determined as 4.5 MPa

FREEZE/THAW DURABILITY TEST

Project:	Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers		
Client:	TRANSPORT CANADA	Contract No.:	1 SD 83 - 00026
Project No.:	314 - 1264.02	Design Maximum Dry Density:	1895 kg/m^3
Sample:	Bashaw	Design Optimum Moisture Content:	9.7 %
	Sand 91 %, Silt 7 %, Clay 2 %	Initial Dry Density:	1831 kg/m^3
		Initial Moisture Content:	9.7 %
		Initial Volume:	948.3 cm^3
Stabilizer Dosage: FUJIBETON	10 %	Volume After Curing:	--- cm^3
FLYASH	%	Final Moisture Content:	12.3 %
CEMENT	%	Stabilized Soil Loss:	1.5 %

Method of Sample Preparation: ASTM D 560 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm^3)	WEIGHT AFTER THAWING AND BRUSHING (g)
1	963.4	1996.1
2	965.4	1974.2
3	942.4	1974.6
4	945.9	1969.2
5	936.8	1962.4
6	945.4	1945.0
7	942.7	1945.4
8	940.5	1936.9
9	930.0	1940.7
10	926.8	1929.5
11	923.1	1921.0
12	935.9	1911.4

Remarks: Unconfined compressive strength after durability test determined as 3.1 MPa

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No: 314 - 1264.02

Design Maximum Dry Density: 1890 kg/m3

Sample: Bashaw

Design Optimum Moisture Content: 9.0 %

Sand 91 %, Silt 7 %, Clay 2 %

Initial Dry Density: 1755 kg/m3

Initial Moisture Content: 10.7 %

Initial Volume: 939.1 cm3

Stabilizer Dosage: FUJIBETON _____ %

Volume After Curing: --- cm3

FLYASH 2 %

Final Moisture Content: 16.9 %

CEMENT _____ %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 560 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm3)	WEIGHT AFTER THAWING AND BRUSHING (g)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated during initial curing period

EBA Engineering Consultants Ltd.

eba

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1845 kg/m³

Sample: Bashaw

Sand 91 %, Silt 7 %, Clay 2 %

Design Optimum Moisture Content: 10.5 %

Initial Dry Density: 1861 kg/m³

Initial Moisture Content: 7.9 %

Initial Volume: 938.3 cm³

Stabilizer Dosage: FUJIBETON ____ %

FLYASH 2 %

CEMENT ____ %

Volume After Curing: --- cm³

Final Moisture Content: 14.8 %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 560 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm³)	WEIGHT AFTER THAWING AND BRUSHING (g)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated during initial curing period

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1890 kg/m3

Sample: Bashaw

Design Optimum Moisture Content: 9.4 %

Sand 91 %, Silt 7 %, Clay 2 %

Initial Dry Density: 1788 kg m3

Initial Moisture Content: 8.6 %

Initial Volume: 954.4 cm3

Stabilizer Dosage: FUJIBETON %

Volume After Curing: --- cm3

FLYASH 4 %

Final Moisture Content: 15.2 %

CEMENT %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 560 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm3)	WEIGHT AFTER THAWING AND BRUSHING (g)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated during initial curing period

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1890 kg/m3

Sample: Bashaw

Design Optimum Moisture Content: 10.1 %

Sand 91 %, Silt 7 %, Clay 2 %

Initial Dry Density: 1898 kg/m3

Initial Moisture Content: 8.2 %

Initial Volume: 956.0 cm3

Stabilizer Dosage: FUJIBETON %

Volume After Curing: --- cm3

FLYASH 4 %

Final Moisture Content: 13.9 %

CEMENT %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 560 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm3)	WEIGHT AFTER THAWING AND BRUSHING (g)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated during initial curing period

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1927 kg/m3

Sample: Bashaw

Design Optimum Moisture Content: 8.5 %

Sand 91 %, Silt 7 %, Clay 2 %

Initial Dry Density: 1824 kg m3

Initial Moisture Content: 7.7 %

Initial Volume: 946.1 cm3

Stabilizer Dosage: FUJIBETON %

Volume After Curing: --- cm3

FLYASH 6 %

Final Moisture Content: 13.9 %

CEMENT %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 560 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm3)	WEIGHT AFTER THAWING AND BRUSHING (g)
1	948.9	1946.4
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated during initial curing period

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264 02

Design Maximum Dry Density: 1900 kg m^3

Sample: Bashaw

Design Optimum Moisture Content: 8.7 %

Sand 91 %, Silt 7 %, Clay 2 %

Initial Dry Density: 1844 kg/m^3

Initial Moisture Content: 10.5 %

Initial Volume: 944.4 cm^3

Stabilizer Dosage: FUJIBETON %

Volume After Curing: --- cm^3

FLYASH 6 %

Final Moisture Content: 14.2 %

CEMENT %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 560 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm^3)	WEIGHT AFTER THAWING AND BRUSHING (g)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated during initial curing period

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264.02

Design Maximum Dry Density: 1945 kg/m3

Sample: Bashaw

Sand 91 %, Silt 7 %, Clay 2 %

Design Optimum Moisture Content: 8.4 %

Initial Dry Density: 1871 kg/m3

Initial Moisture Content: 7.8 %

Initial Volume: 958.8 cm3

Stabilizer Dosage: FUJIBETON _____ %

FLYASH 10 %

CEMENT _____ %

Volume After Curing: --- cm3

Final Moisture Content: 16.2 %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 560 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm3)	WEIGHT AFTER THAWING AND BRUSHING (g)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated during initial curing period

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Project No.: 314 - 1264.02

Sample: Bashaw

Sand 91 %, Silt 7 %, Clay 2 %

Stabilizer Dosage: FUJIBETON ______ %

FLYASH 10 %

CEMENT ______ %

Contract No.: 1 SD 83 - 00026

Design Maximum Dry Density: 1909 kg/m3

Design Optimum Moisture Content: 9.1 %

Initial Dry Density: 1933 kg/m3

Initial Moisture Content: 9.2 %

Initial Volume: 943.6 cm3

Volume After Curing: --- cm3

Final Moisture Content: 12.4 %

Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 560 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm^3)	WEIGHT AFTER THAWING AND BRUSHING (g)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated during initial curing period

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA

Contract No.: 1 SD 83 - 00026

Project No.: 314 - 1264 02

Design Maximum Dry Density: 1910 kg/m3

Sample: Bashaw

Design Optimum Moisture Content: 9.0 %

Sand 91 %, Silt 7 %, Clay 2 %

Initial Dry Density: 1797 kg/m3

Initial Moisture Content: 8.6 %

Initial Volume: 946.1 cm3

Stabilizer Dosage: FUJIBETON %

Volume After Curing: --- cm3

FLYASH 3 %

Final Moisture Content: 14.9 %

CEMENT 2 %

Stabilized Soil Loss: 54 %

Method of Sample Preparation: ASTM D 560 - 57 but sample statically compacted to approximately 95 % of field design maximum dry density.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm3)	WEIGHT AFTER THAWING AND BRUSHING (g)
1	952.1	1905.4
2	941.8	1847.4
3	926.5	1805.6
4	852.4	1762.6
5	870.5	1695.5
6	848.5	1579.0
7	832.8	1511.4
8	649.4	1360.1
9	806.2	1300.5
10	607.2	1159.9
11	473.3	1035.5
12	496.9	908.4

Remarks: Unconfined compressive strength after durability test determined as 0.38 MPa

FREEZE/THAW DURABILITY TEST

Project: Laboratory Evaluation of Flyash Cement and Lignin Cellulose Cement as Soil Stabilizers

Client: TRANSPORT CANADA	Contract No.: 1 SD 83 - 00026
Project No.: 314 - 1264.02	Design Maximum Dry Density: 1888 kg/m³
Sample: Bashaw	Design Optimum Moisture Content: 9.5 %
Sand 91 %, Silt 7 %, Clay 2 %	Initial Dry Density: 1825 kg/m³
	Initial Moisture Content: 9.8 %
	Initial Volume: 952.4 cm³
Stabilizer Dosage: FUJIBETON ____ %	Volume After Curing: --- cm³
FLYASH 3 %	Final Moisture Content: 13.2 %
CEMENT 2 %	Stabilized Soil Loss: 100 %

Method of Sample Preparation: ASTM D 560 - 57 but sample dynamically compacted using 75 % of standard compactive effort.

TEST DATA:

CYCLE	VOLUME AFTER THAWING AND BRUSHING (cm³)	WEIGHT AFTER THAWING AND BRUSHING (g)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Remarks: Sample disintegrated during initial curing period